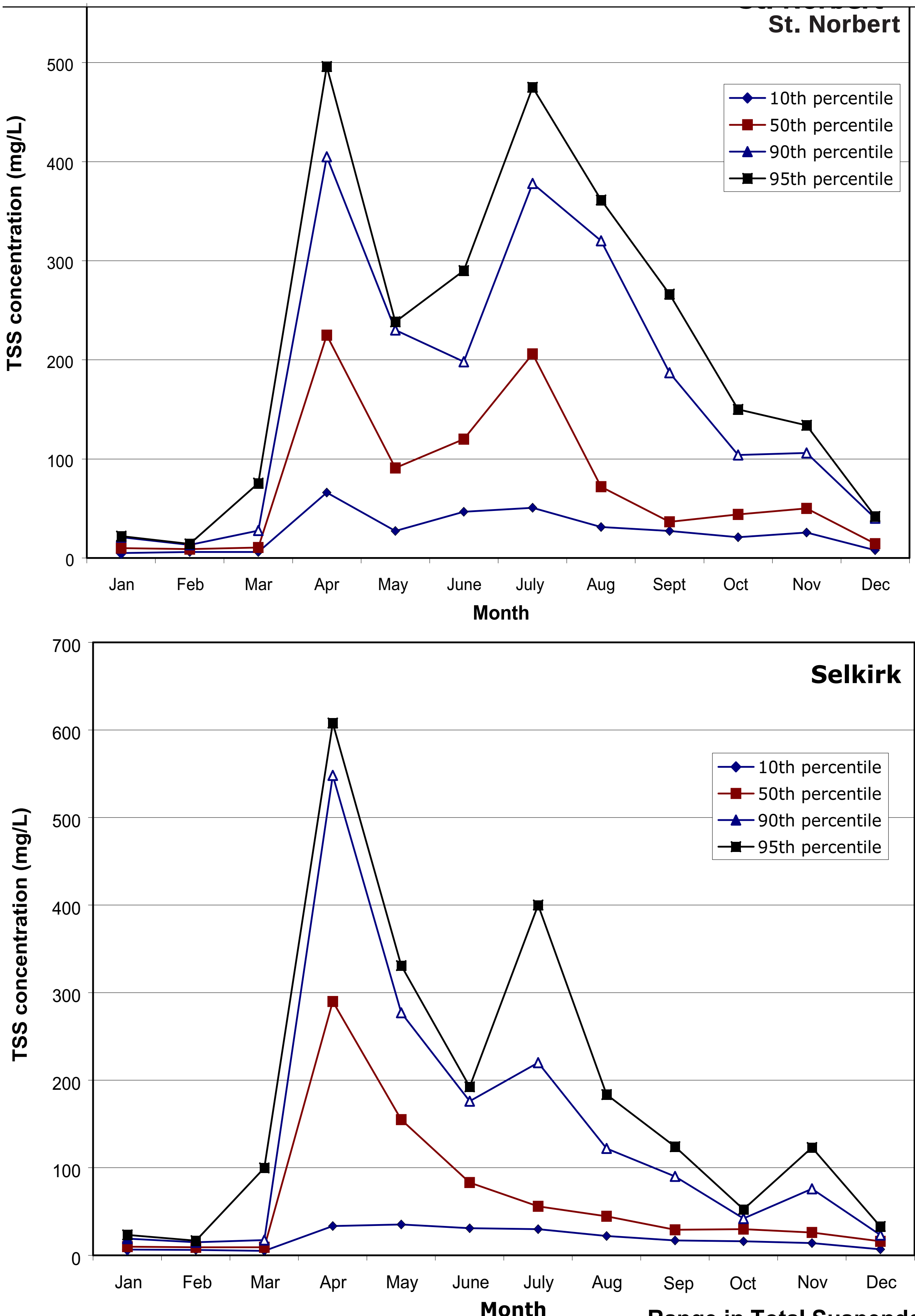
APPENDIX 6

Aquatic Environment

LIST OF APPENDICES

APPENDIX 6A

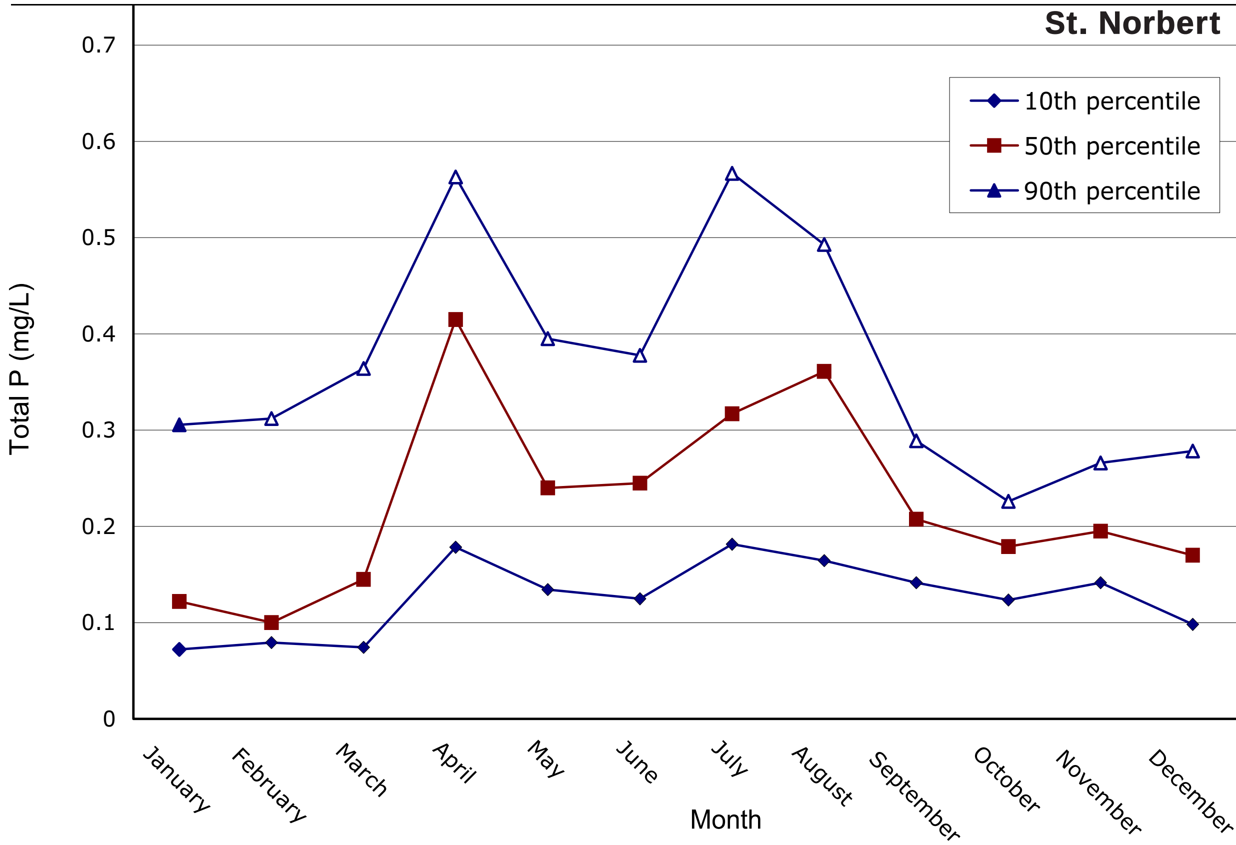
Surface Water Quality Data

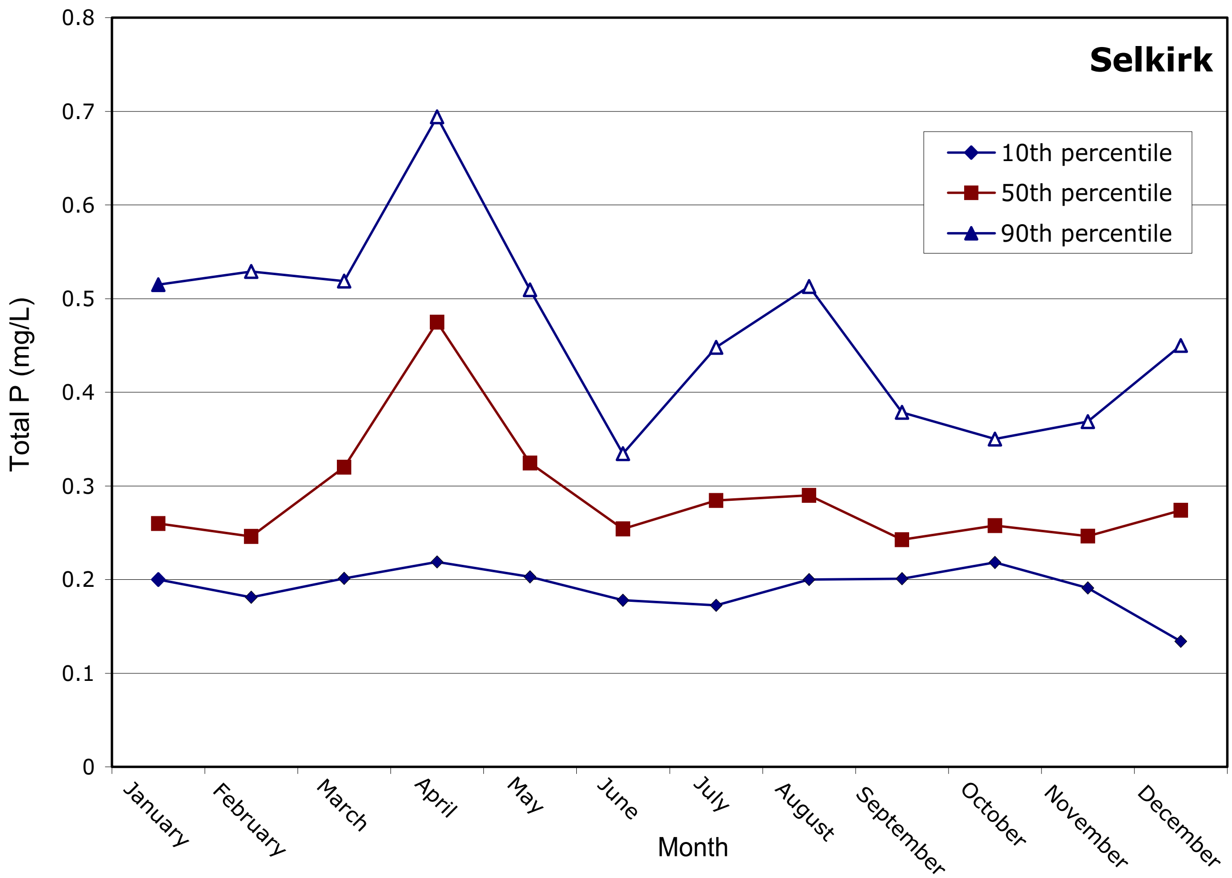


Range in Total Suspended Solids Concentrations in the Red River at St. Norbert and Selkirk

Figure 6A-1

tssrang
ms\01\0211\09

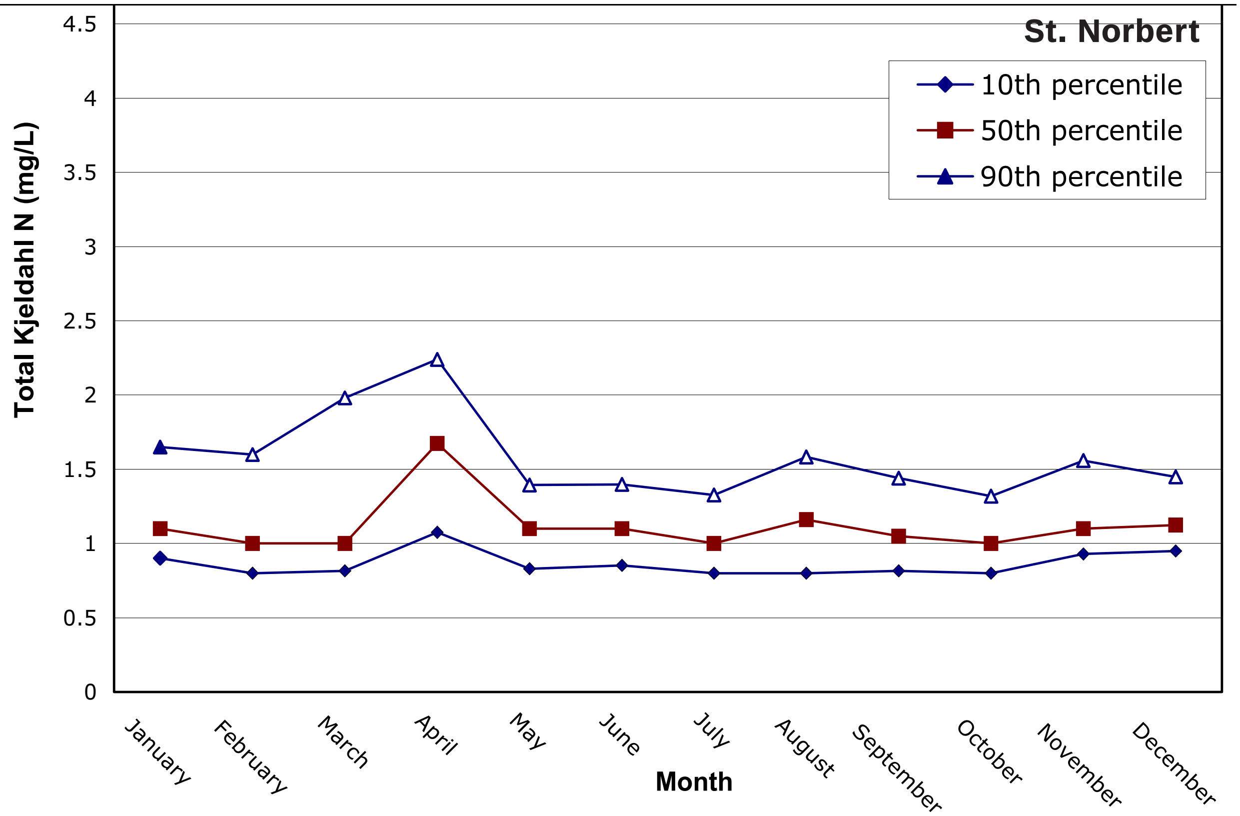


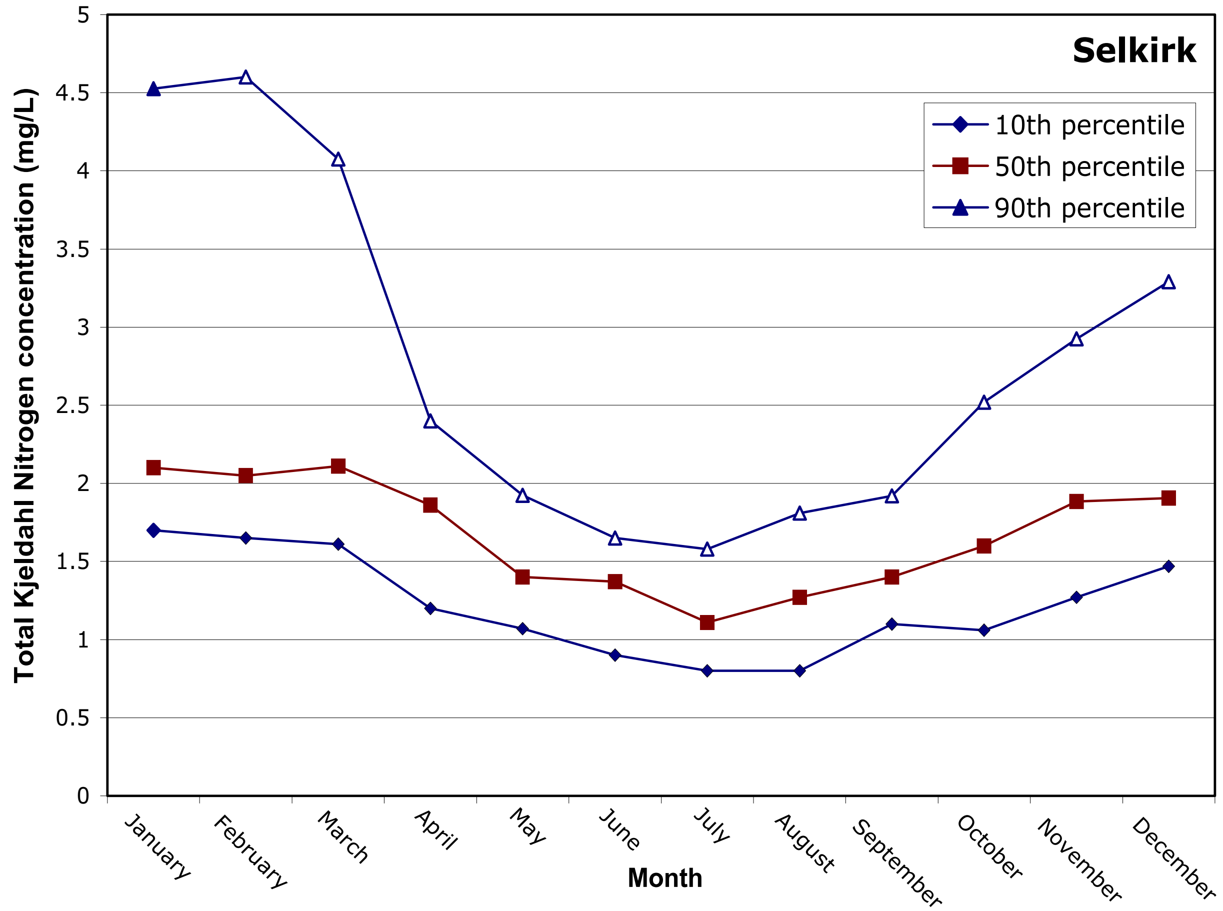


Range in Total Phosphorous Concentrations in the Red River at St. Norbert and Selkirk

Figure 6A-2

totPrang
ms\01\0211\09

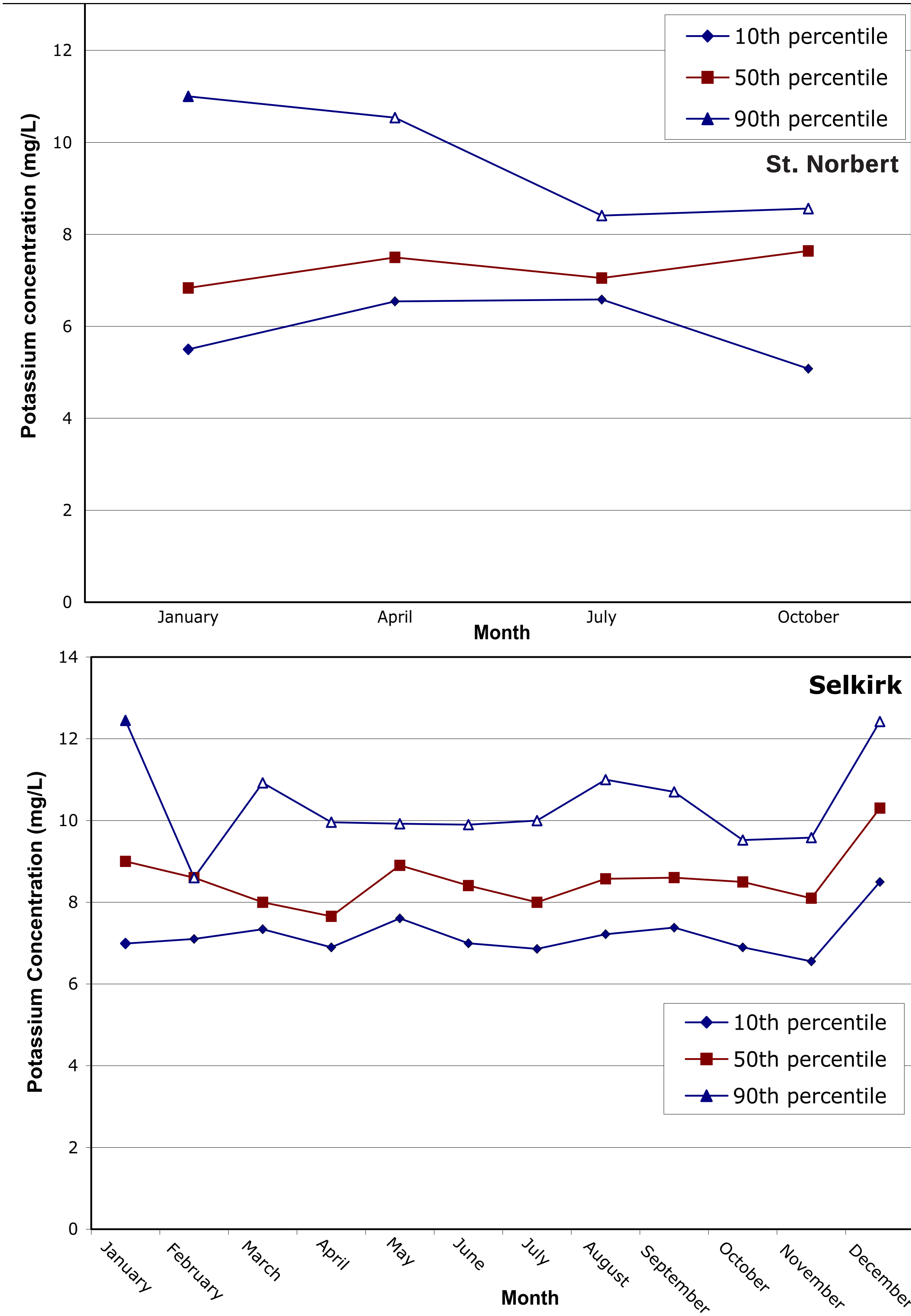




Seasonal Concentrations of Total Kjeldahl Nitrogen Concentrations in the Red River at St. Norbert and Selkirk

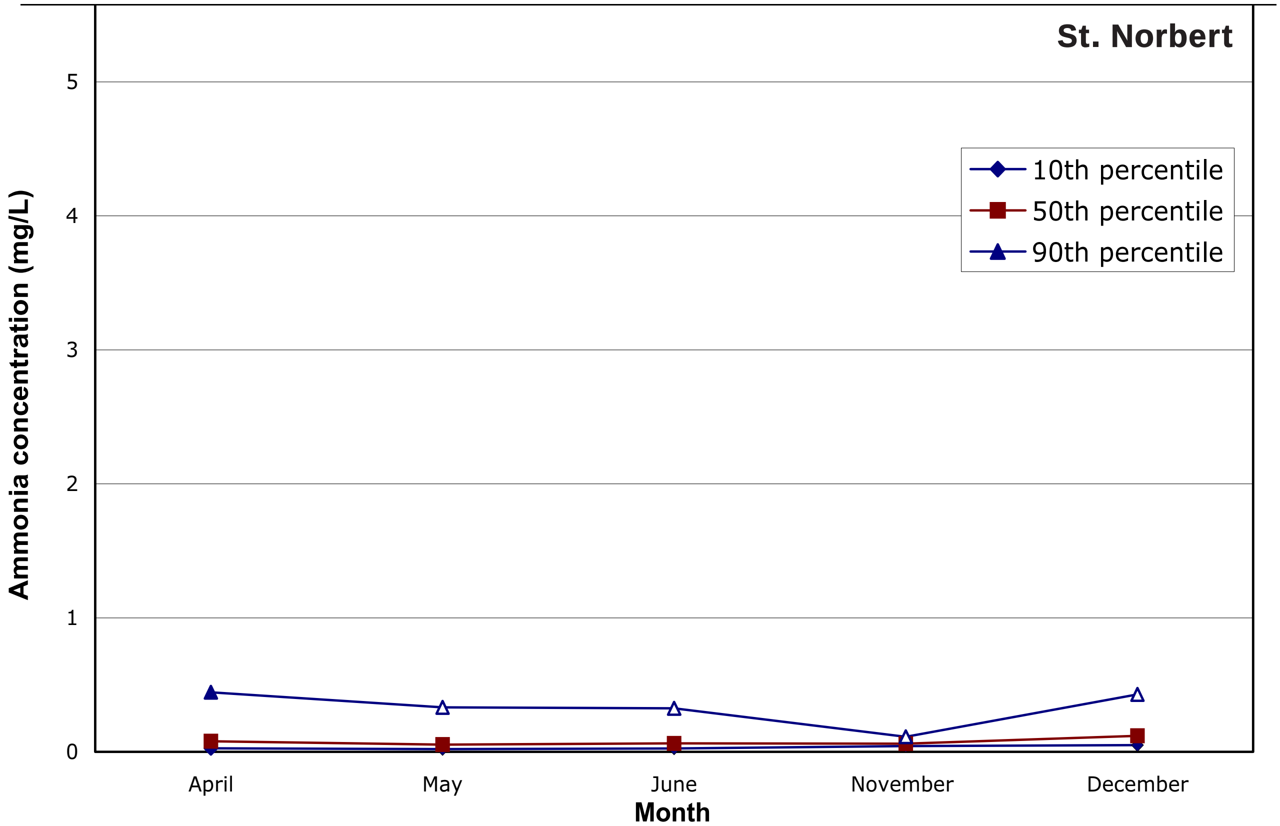
Figure 6A-3

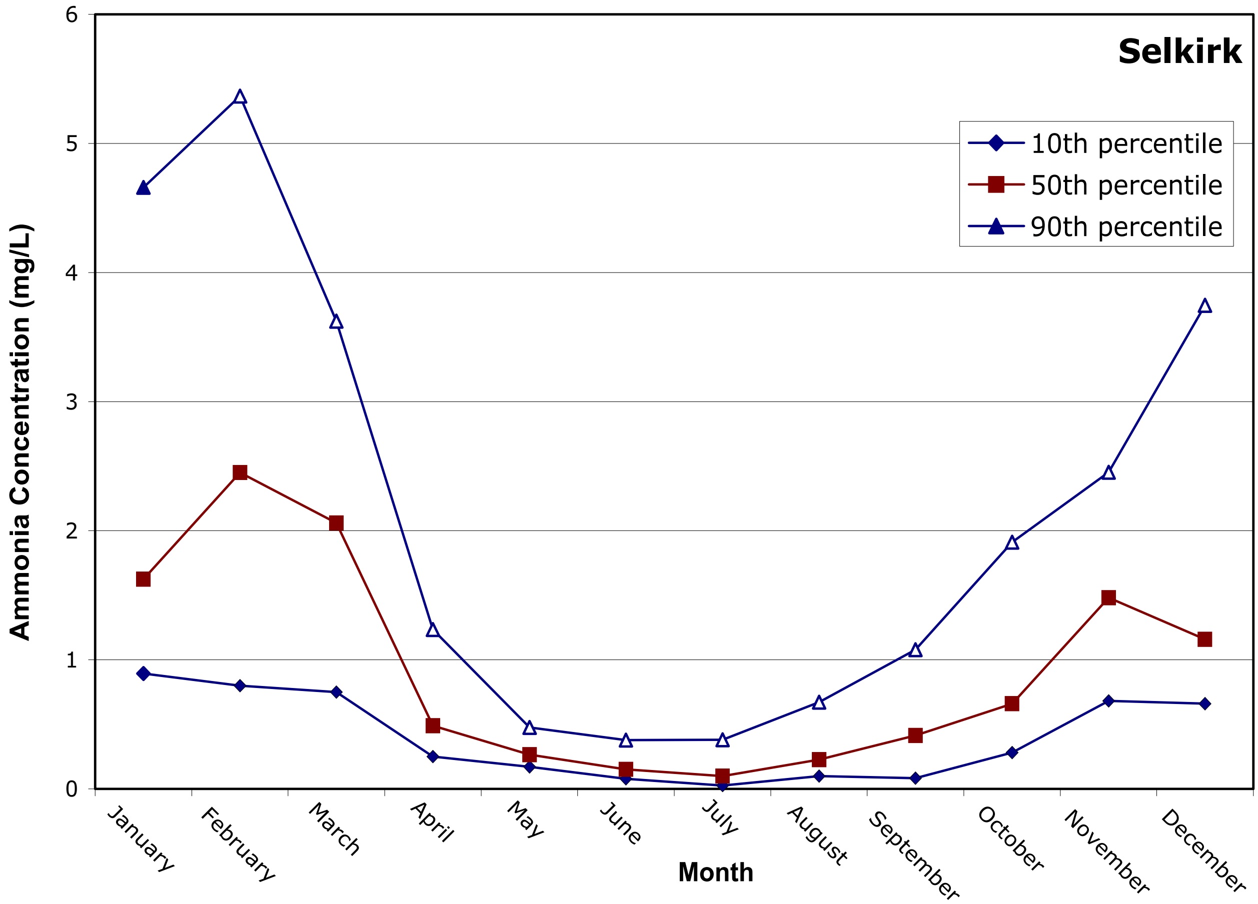
tknrang
ms\01\0211\09



Seasonal Concentrations of Potassium in the Red River at St. Norbert and Selkirk
Figure 6A-4

potrang
ms\01\0211\09





Seasonal Concentrations of Total Unionized Ammonia in the Red River at St. Norbert and Selkirk

Figure 6A-5

nh3rang
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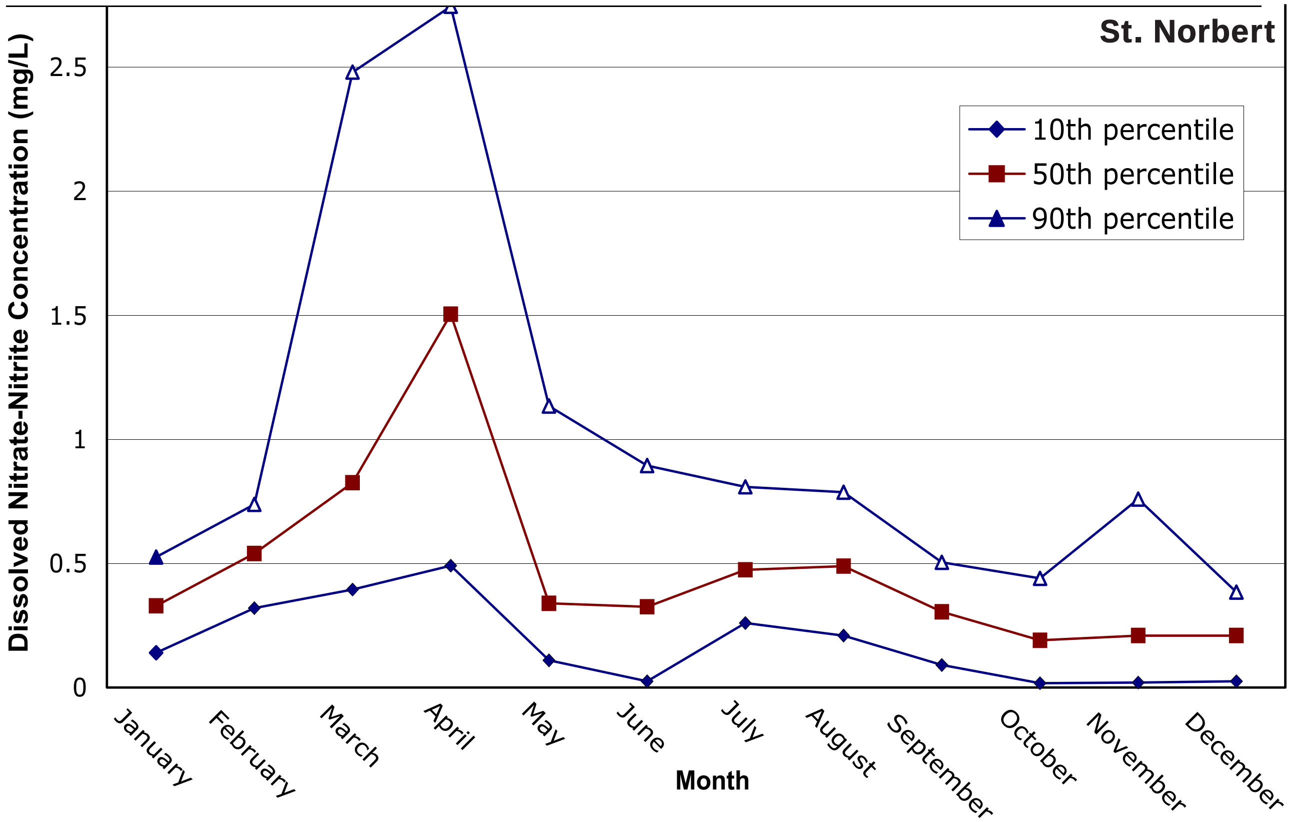

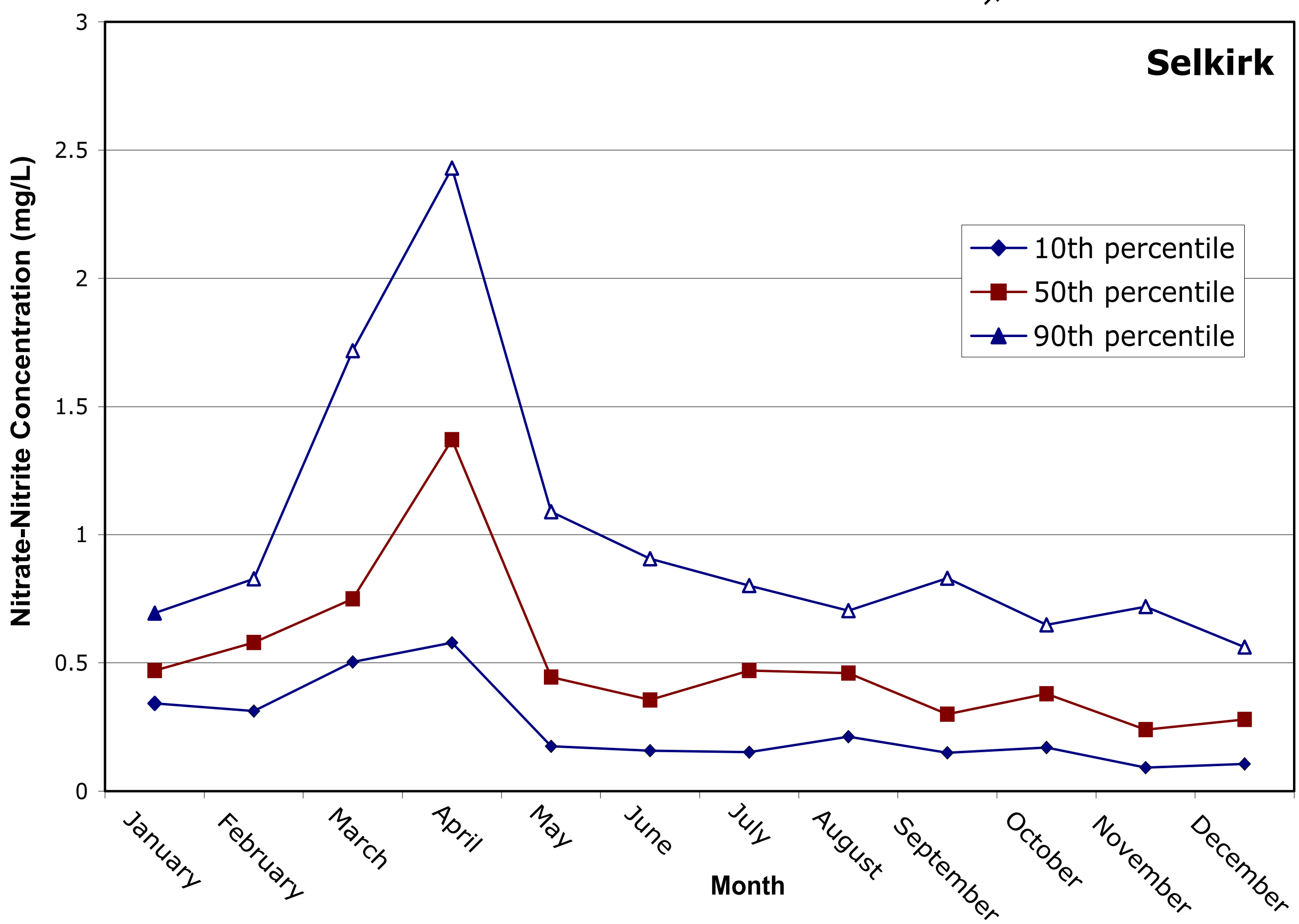

Seasonal Nitrate-Nitrite Concentrations in the Red River at St. Norbert and Selkirk

Figure 6A-6

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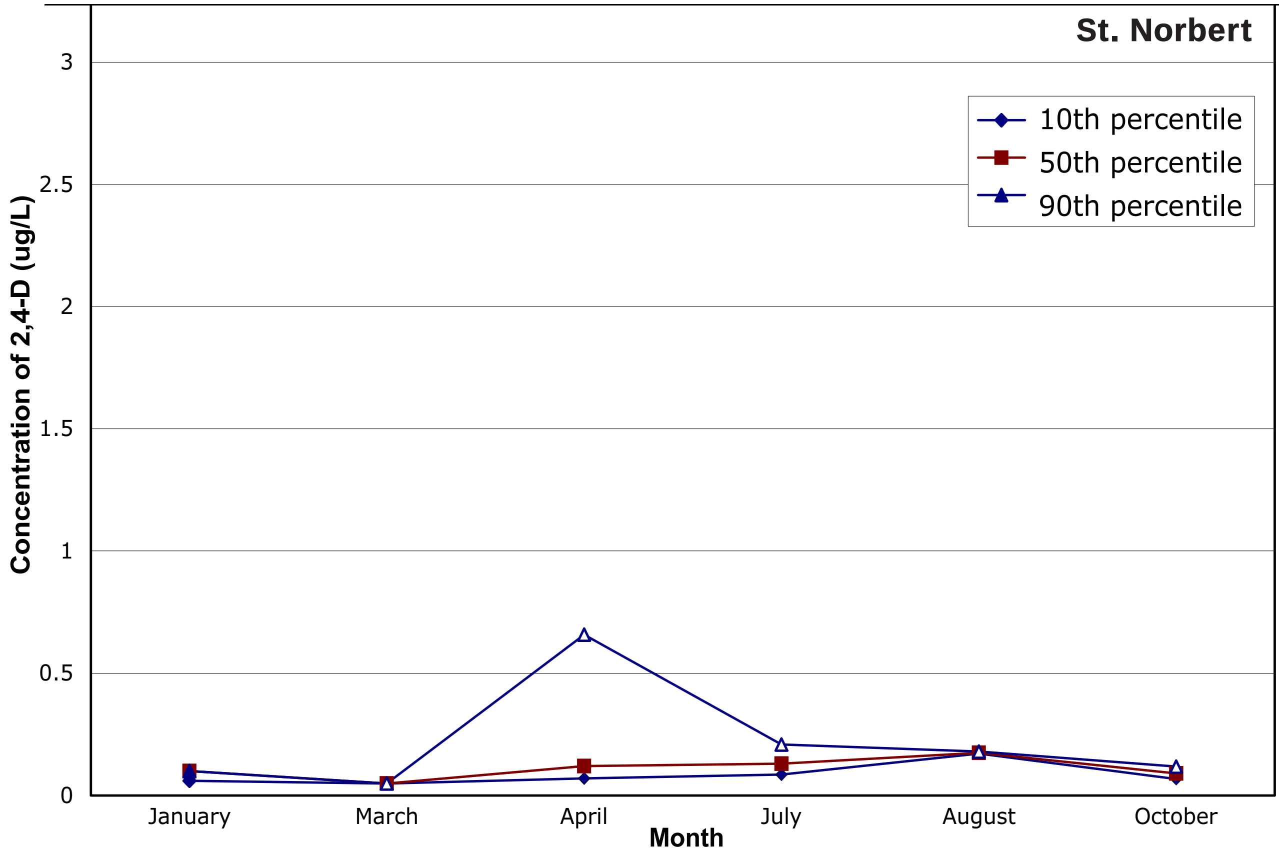

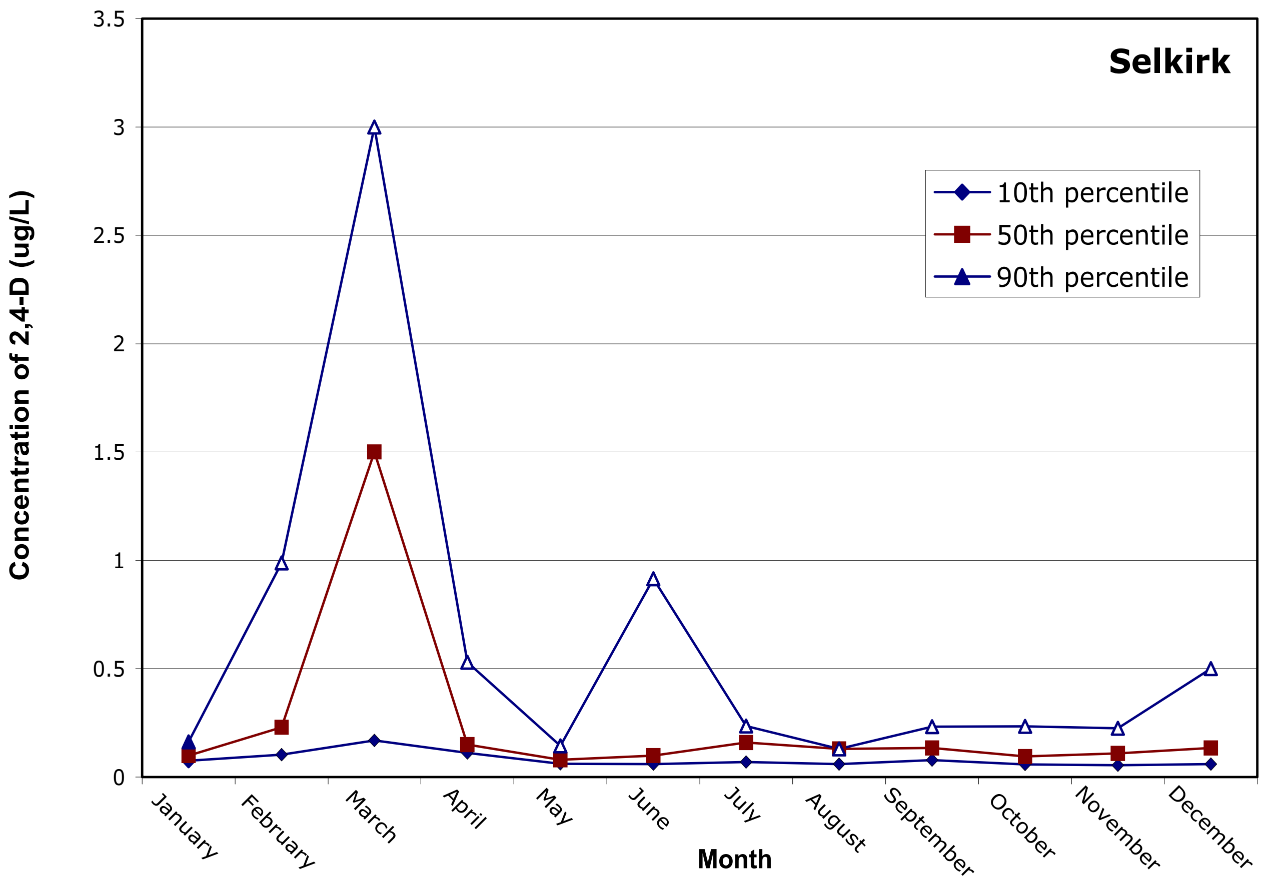

Seasonal Concentrations of 2,4-D in the Red River at St. Norbert and Selkirk

Figure 6A-7

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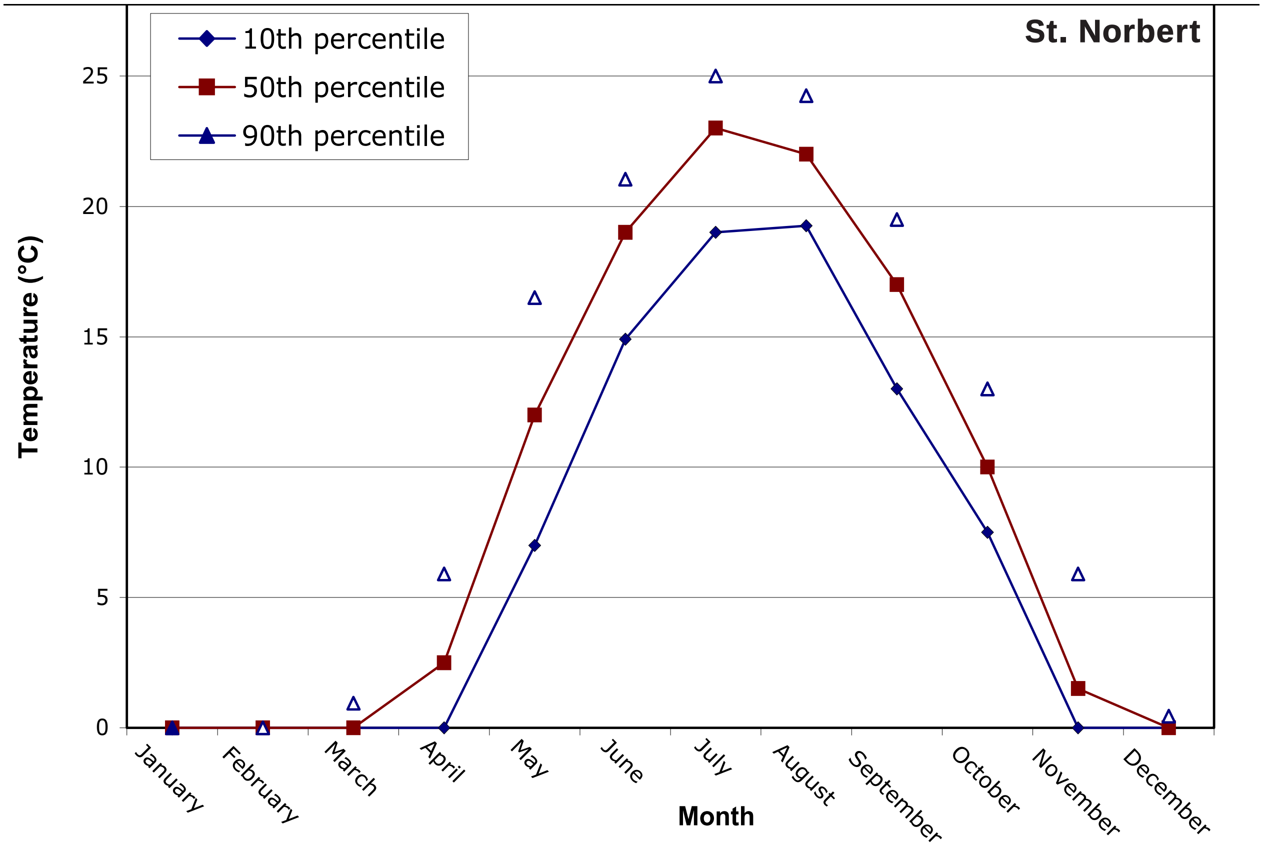

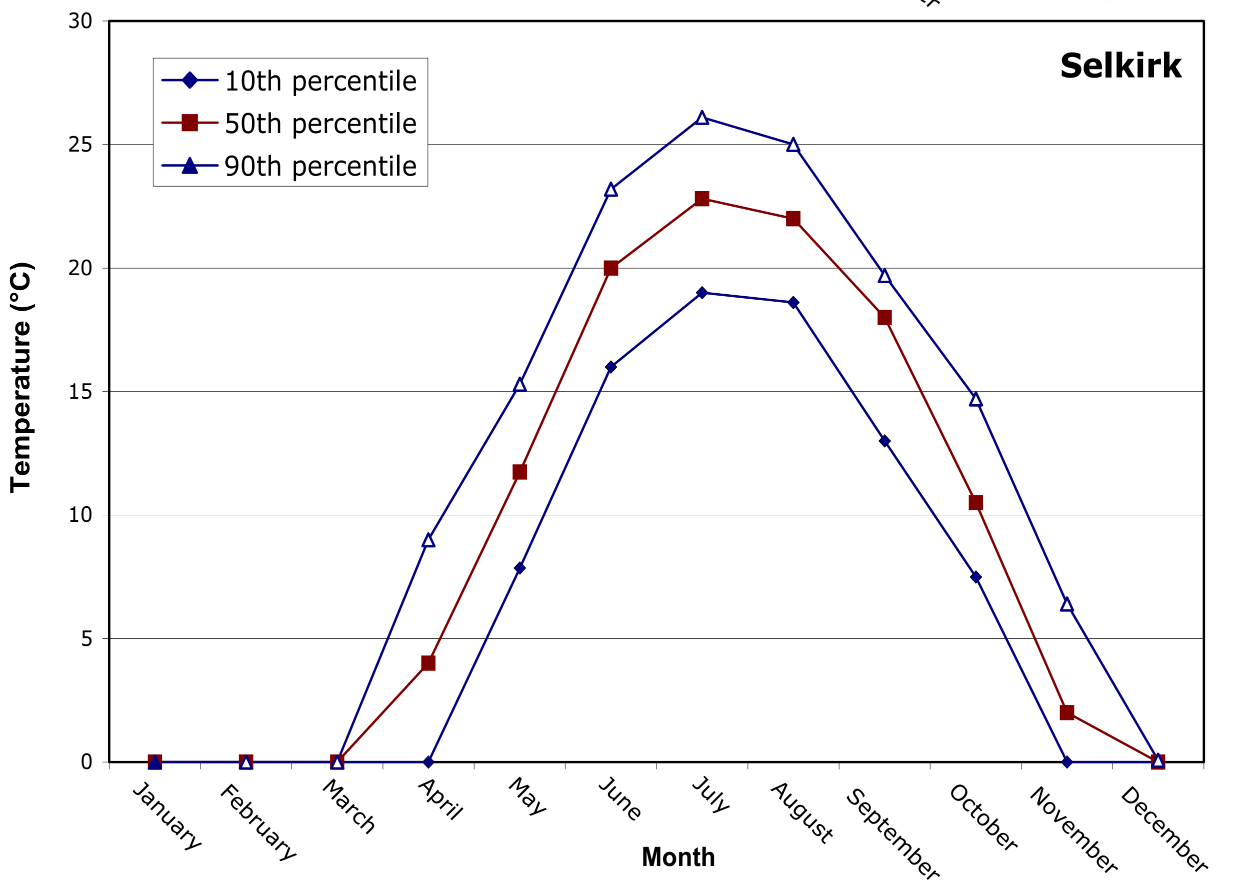

Seasonal Variations in Temperature in the Red River at St. Norbert and Selkirk
Figure 6A-8

temprang
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APPENDIX 6B

"Worst-case" Scenario Calculation of Potential Fertilizer and Herbicide Loading

Table 6B-1
Flow at Lockport

Date	Maximum Flow (cubic metres/second)	Mean Flow (cubic metres/second)	Minimum Flow (cubic metres/second)
01-May	4040	939.605675	36.2806
02-May	4180	925.4063222	35.5731
03-May	4260	901.7488861	36.0825
04-May	4320	883.0821722	39.6766
05-May	4320	865.2852639	42.7613
06-May	4320	849.5537556	44.6857
07-May	4080	830.1582611	52.9776
08-May	3680	806.7439056	49.5816
09-May	3400	782.8851028	43.2707
10-May	3370	760.0070028	43.865
11-May	3200	736.37005	44.4876
12-May	3060	714.7196	42.9877
13-May	3030	697.6637139	42.9877
14-May	2930	678.6681222	44.6857
15-May	2780	660.2921333	50.9683
16-May	2700	638.7859611	48.4779
17-May	2610	618.35515	45.9592
18-May	2550	603.2826389	42.9877
19-May	2490	594.7925667	38.0635
20-May	2440	578.1445194	33.5921
21-May	2390	574.3764417	30.9885
22-May	2330	565.1404083	33.394
23-May	2270	551.2386833	43.7801
24-May	2240	539.9106056	47.8836
25-May	2210	525.4360167	50.0627
26-May	2190	512.4526806	52.072
27-May	2150	503.1368278	52.355
28-May	2050	480.1425806	65.9673
29-May	1930	464.3771639	65.656
30-May	1840	453.1487028	68.1464
31-May	1740	440.5510056	63.8731
01-Jun	1590	425.5419972	64.8636
02-Jun	1400	406.5509278	63.958
03-Jun	1400	393.6176639	63.958
04-Jun	1420	387.5903667	61.977
05-Jun	1350	377.051175	62.26
06-Jun	1310	367.1458917	62.8543
07-Jun	1300	359.3529444	63.0524
08-Jun	1240	350.5293333	58.1565
09-Jun	1220	347.8962278	54.5624
10-Jun	1120	339.2914528	52.5814
11-Jun	1040	330.80935	50.374
12-Jun	977	322.9941278	49.5816
13-Jun	905	318.4330917	44.6857
14-Jun	848	313.7931861	43.582

Table 6B-1
Flow at Lockport

Date	Maximum Flow (cubic metres/second)	Mean Flow (cubic metres/second)	Minimum Flow (cubic metres/second)
15-Jun	789.5417	311.8983528	42.9877
16-Jun	778.533	309.6168639	41.0633
17-Jun	769.5336	307.4817194	39.3653
18-Jun	795.513	304.6664611	38.771
19-Jun	874.47	304.0209306	40.7803
20-Jun	860.4898	303.1422611	41.2614
21-Jun	860.4898	298.9281333	39.3653
22-Jun	860.4898	295.0567389	37.6673
23-Jun	877.4698	292.2765056	36.1674
24-Jun	888.4785	290.3238167	35.092
25-Jun	894.4781	286.8976972	33.394
26-Jun	851.4904	285.9216	31.0734
27-Jun	803.5219	283.0881694	31.3847
28-Jun	798.5128	280.9664056	31.979
29-Jun	854.4902	278.9338139	33.394
30-Jun	803.5219	273.1425778	32.7714
01-Jul	735.5736	267.0811833	31.6677
02-Jul	766.5338	268.7288972	30.8753
03-Jul	814	268.8575139	29.3754
04-Jul	870	270.4212389	29.9697
05-Jul	905	268.4185694	31.3847
06-Jul	919	266.3099444	33.0827
07-Jul	918	261.5284806	33.9883
08-Jul	910	260.2601472	33.394
09-Jul	931.4379	259.2533917	31.6677
10-Jul	950.4272	258.8507444	30.8753
11-Jul	967.4355	258.7678917	34.2713
12-Jul	982.4062	262.1150889	39.8747
13-Jul	993.4149	260.6858361	45.8743
14-Jul	1009.4044	254.7128	45.28
15-Jul	1009.4044	249.6240611	43.865
16-Jul	1019.3943	246.8000972	41.0633
17-Jul	1029.3842	244.0269389	37.6673
18-Jul	1049.364	239.1807667	35.092
19-Jul	1059.3822	236.0493611	36.1674
20-Jul	1079.362	231.7427194	36.79
21-Jul	1099.3418	228.9199528	36.4787
22-Jul	1119.3216	226.4312722	35.9693
23-Jul	1129.3398	224.3922861	34.7807
24-Jul	1139.3297	224.9977889	33.1676
25-Jul	1139.3297	223.1110389	31.2715
26-Jul	1149.3196	226.9568139	29.1773
27-Jul	1139.3297	230.997	27.8755
28-Jul	1129.3398	232.6801667	25.9794
29-Jul	1179.2893	228.7255639	23.489

Table 6B-1
Flow at Lockport

Date	Maximum Flow (cubic metres/second)	Mean Flow (cubic metres/second)	Minimum Flow (cubic metres/second)
30-Jul	1229.2671	221.8951583	21.6778
31-Jul	1239.257	215.7491861	20.376
01-Aug	1199.2974	205.4860972	18.678
02-Aug	1169.2994	196.8825111	18.395
03-Aug	1129.3398	185.4009778	18.1969
04-Aug	1099.3418	174.1028778	21.1967
05-Aug	1059.3822	163.3778694	20.1779
06-Aug	1049.364	157.428525	18.1969
07-Aug	1039.3741	151.1859722	18.678
08-Aug	1029.3842	146.2818861	18.2818
09-Aug	1149.3196	145.3853889	17.3762
10-Aug	1259.2368	143.1732111	16.5838
11-Aug	1259.2368	140.8297583	16.1027
12-Aug	1239.257	138.4045444	15.4801
13-Aug	1229.2671	135.9738444	15.3952
14-Aug	1249.2469	133.9186472	16.7819
15-Aug	1269.255	133.1988111	15.9895
16-Aug	1299.2247	131.9019583	16.1876
17-Aug	1249.2469	130.3731861	17.4894
18-Aug	1209.2873	128.8444472	22.4985
19-Aug	1159.3095	127.6846639	22.7815
20-Aug	1119.3216	127.1514389	23.0928
21-Aug	1069.3721	127.6868417	23.8852
22-Aug	1029.3842	127.6058944	24.6776
23-Aug	979.4064	126.5050639	25.3851
24-Aug	934.4377	125.7998944	24.7908
25-Aug	896.4591	124.983625	24.0833
26-Aug	864.4801	123.2384139	18.9893
27-Aug	815.5211	123.2252639	17.8007
28-Aug	754.5629	122.0287694	17.3762
29-Aug	696.5762	119.2584972	17.4894
30-Aug	648.6077	117.1441111	18.678
31-Aug	606.6388	116.1743194	19.4987
01-Sep	569.6507	113.9849944	20.4892
02-Sep	538.6905	110.8882222	19.8949
03-Sep	512.6828	107.086825	19.3855
04-Sep	500.7119	104.2707	19.1025
05-Sep	501.7024	102.3989472	18.395
06-Sep	510.7018	101.2719389	17.9988
07-Sep	518.6824	102.1592278	17.0932
08-Sep	519.7012	101.965575	16.8951
09-Sep	513.7016	100.2971611	16.1876
10-Sep	501.7024	98.75033611	15.9895
11-Sep	482.7131	98.49432222	16.3008
12-Sep	458.7147	99.43558889	16.697

Table 6B-1
Flow at Lockport

Date	Maximum Flow (cubic metres/second)	Mean Flow (cubic metres/second)	Minimum Flow (cubic metres/second)
13-Sep	431.7448	100.3113278	18.0837
14-Sep	403.7561	100.2607528	18.2818
15-Sep	378.7672	98.68958611	18.0837
16-Sep	357.7969	97.38310833	17.8856
17-Sep	339.7981	95.11151944	17.6875
18-Sep	327.7989	93.22401944	17.4894
19-Sep	314.8092	92.67901667	18.1969
20-Sep	299.8102	94.63240278	19.3006
21-Sep	329	95.48387778	19.4987
22-Sep	370	95.90765278	19.3855
23-Sep	386	95.39356389	19.3855
24-Sep	379	93.910925	19.7817
25-Sep	362	93.11584444	22.9796
26-Sep	334	92.23166944	25.2719
27-Sep	310	92.05518056	22.7815
28-Sep	293	92.28716389	24.4795
29-Sep	276	92.04081944	28.9792
30-Sep	261	90.98818889	27.4793

Table 6B-2

Calculations of Minimum, Average and Maximum Flow Rates at Lockport

Month	Flow (m^3/s)	Total volume
May	667	1,786,359,910
June	325	842,137,325
July	468	1,254,541,660
August	226	604,353,576
September	173	447,369,873

Average daily flow from May to September (cubic metres/second)	Estimated mean volume of water from May 1 to Sept 30 inclusive (cubic metres)
296	3,917,206,775

Minimum data flow from May 1 to September 30 inclusive	Estimated minimum volume of water from May 1 to Sept 30 inclusive (cubic metres)
33	426,853,228

Maximum data flow from May 1 to Sept 30 inclusive (cubic metres/per second)	Estimated maximum volume of water from May 1 to Sept 30 inclusive (cubic metres)
1,296	17,127,719,076

Table 6B-3
Calculations of Fertilizer and Herbicide Loading Rates under a "Worst-Case" Scenario

Substance	Glyphosate	2,4-D amine	Nitrogen	Phosphorous	Potassium
Amount used (pounds)	2760	180	72000	156000	108000
Amount Used (kilograms)	1,252	82	32,659	70,760	48,988
Amount Used (grams)	1,251,914	81,647	32,658,624	70,760,352	48,987,936
Approximate average volume of water (cubic metres), based on daily means	3,917,206,775				
Potential Concentrations based on average water flows (nutrients are total nutrients), mg/L	0.0003	0.0000	0.0083	0.0181	0.0125
Approximate minimum volume of water (cubic metres), based on daily minimums	426,853,228				
Potential concentrations based on minimum water flows (mg/L)	0.0029	0.0002	0.0765	0.1658	0.1148
Approximate maximum volume of water (cubic metres), based on daily maximums	17,127,719,076				
Potential concentrations based on maximum water flows (mg/L)	0.0001	0.0000	0.0019	0.0041	0.0029

Table 6B-4
Comparison of "worst-case" changes in Surface Water Quality to Baseline Concentrations

Substance and unit of measure		Glyphosate (ug/L)	2,4-D amine (ug/L)	Total phosphorous (mg/L)	Total Nitrogen (mg/L)	Total Potassium (mg/L)
Projected maximum amount used in one season (kg)		1,252	180	71,000	33,000	49,000
Typical (mean and 90th percentile) concentrations of substance in Red River at Selkirk	50th percentile	below detectable limi	0.12	0.264	1.3	8.6
	90th percentile	below detectable limi	0.232	0.4448	1.888	10.47
Potential "worst-case" scenario increase in concentration during one year	Based on minimal	2.9329	0.1913	0.0765	0.1658	0.1148
	Based on average flows	0.3196	0.0208	0.0181	0.0083	0.0125

APPENDIX 6C

Aquatic Species Lists

TABLE 6C-1
Fish Species of the Red River and their Ecology

FISH SPECIES OF THE RED RIVER				STATUS		SPAWNING		Habitat	
Order	**Family**	**Scientific Name**	**Common name**	**KWS***	**MAIN CHANNEL**	**Time**	**Habitat**	**JUVENILE**	**ADULT**
Petromyzontiformes	Petromyzontidae	*Ichthyomyzon castaneus*	chestnut lamprey	N	Yes	early - mid June but as late as July	tributary streams; gravel/sand bottoms of medium current	ammocoetes: drift downstream burrow into soft bottom	main course of rivers
		Ichthyomyzon unicuspis	silver lamprey	N	Yes		larger rivers in gravelly riffles	ammocoetes: burrow in mud annd silt at edge of river	larger rivers and lakes
Acipenseriformes	Acipenseridae	*Acipenser fluvescens*	lake sturgeon	N, R	Yes	early May - late June; don't spawn annually	swift water, rapids, 0.4-4.5 m depth,	highly productive shoal areas in lakes, large rivers	highly productive shoal areas in lakes, large rivers
Osteoglossiformes	Hiodontidae	*Hiodon alsoides*	goldeye	N	Yes	May - early July	pools in turbid rivers	quiet turbid waters of large rivers	quiet turbid waters of large rivers
		Hiodon tergisus	mooneye	N	Yes	late May-June(?)	over rocks in swift water areas		
Cypriniformes	Cyprinidae	*Carassius auratus*	goldfish	I	No (or rare)	May to June	warm, weedy shallows		
		Cypinella spiloptera	spotfin shiner	N	Yes	late May-mid-August (2)	dependant on bottom substrate, depth, current		large rivers, sand and gravel substrate, somewhat turbid waters
		Cyprinus carpio	common carp	I	Yes	late April - June	weedy, grassy shallows	remain in spawning areas	warm lakes, streams, ponds with organic matter
		Hybognathus hankinsoni	brassy minnow	N, Pembina River	No	May-June (2)	migration from lakes to tributary streams, silt bottom, sand bottom		cool, dark acid waters of silt-bottomed bog ponds
		Luxilus comutus	common shiner	N, Tributary	No	May - July (2)	tributaries on gravel in flowing water, at the head of gravelly riffles		pools and slower stretches of medium and small sized streams; over substrate ranging from silt and sand to gravel; prefers open water with beds of aquatic vegetation
		Macrhybopsis storeriana	silver chub	N	Yes	June-July (2)	unknown		slow-moving water over soft substrates
		Margariscus margarita	pearl dace	N, Pembina River	No	May (2)	over substrates ranging from gravel to silt in quiet or flowing water 45 to 60 cm deep; male defends territory but no nest constructed		cool, clear flowing waters in stained, tea-coloured water; associated with bog habitats in headwater streams and ponds
		Nocomis biguttatus	hornyhead chub	1 record (erroneous?)	Yes	May-July (3)	nests of stones/pebbles built by male on fine gravel/pebble substrate below riffles in shallow water	along shorelines, in beds of aquatic vegetation, water depths of 30cm to 1m, over silty sand or gravel substrate	quiet, clear waters with aquatic vegetation in ponds, oxbow lakes or streams; over soft substrates < 2m deep; tolerant of low oxygen levels and can survive in waters subject to winter kill

FISH SPECIES OF THE RED RIVER				STATUS		SPAWNING		Habitat	
Order	Family	Scientific Name	Common name	KWS*	MAIN CHANNEL	Time	Habitat	JUVENILE	ADULT
		Notemigomus chrysoleucas	golden shiner	N, rare	No	May - August	clear, quiet, weedy shores and tributaries	same as spawning	surface to mid-water, clear weedy shores, still to slow current, mud substrate with weed beds
		Notropis atherinoides	emerald shiner	N	Yes	late June - early August (1)	gravel shoals of riverbeds and tributaries	mid-water to surface	still to moderate current of variety of substrates
		Notropis blennius	river shiner	N	Yes	Late June-August (1)	over sand, gravel bottom		
		Notropis dorsalis	bigmouth shiner	N, Roseau & Pembina Rivers	No	May-August (2)	likely mid-water		bottom to mid-water, slow to moderate current, clear to turbid waters, unstable sandy silt substrate, intolerant of high turbidity
		Notropis hudsonius	spottail shiner		Yes	June-July (2)	sandy shoals, gravel, riffles		large lakes and rivers, mid-water to bottom, still to moderate current; mud, sand, gravel, weedy substrate
		Notropis stramineus	sand shiner	N, trib	Yes	Jun-July (1)			sandy shallows of river margins with sparse growth of rooted aquatic plants
		Phoxinus eos	northern redbelly dace	N, Rat River	No	May-August (2)			boggy lakes, creeks, and ponds; quiet waters; substrate of fine detritus or silt
		Phoxinus neogaeus	finscale dace	N, Rat River	No	June? (2)	stained cool boggy lakes, streams and larger lakes		bog ponds, streams and lakes
		Pimephales notatus	bluntnose minnow	N, 1 record	Yes	May - August (2)			
		Pimrphales promelas	fathead minnow	N	Yes	June - August	under logs, rocks, and debris in quiet, shallow water	quiet, weedy shallows	still turbid waters, bottom to surface, mud gravel, rubble with vegetation
		Plalygobio gracillis	flathead chub	N, lower reach	Yes	Probably June (2)	in gravel or rubble, in fast water	shallow riffles, on gravel bottom	turbid main channels; bottom up to 2 m, fast current, sand, gravel, or rubble substrate
		Rhinichthys cataractae	longnose dace	N	Yes	May (1)	among boulders in rapids	quiet waters near shore	clean, swiftly flowing, gravel or boulder streams; at time in very turbulent waters
		Rhinichthys obtusus	western blacknose dace	N	No	late May (1)	over gravel and silt in fast water of shallow riffles few inches deep		rivers and tributaries moderate to fast current, gravel substrate
		Semotilus atromaculatus	creek chub	N	No	May - early June (1)	small gravelly tributaries in smooth water above or below riffles	spawning tributaries of smooth waters	variety of current with variety of tributary substrates that are silt free

FISH SPECIES OF THE RED RIVER				STATUS		SPAWNING		Habitat	
Order	Family	Scientific Name	Common name	KWS*	MAIN CHANNEL	Time	Habitat	JUVENILE	ADULT
	Catostomidae	*Carpiodes cyprinus*	quillback	N	Yes	April (1)	tributaries on mud in quiet water	bottom, main channel, on mud and sand	bottom, slow to moderate current, sand, silt, mud substrate
		Catostomus commersoni	white sucker	N	Yes	early April-June (1)	in fast water over gravel in main channel and tributaries	moderate to fast waters of river margins	warm shallow lakes, warm shallow bays, and tributary rivers of larger lakes
		Ictiobus cyprinellus	bigmouth buffalo	N	Yes	mid May - early June	shallow water of small tributary streams and marshes of large lakes, flood lake margins		shallow depths in slow, sluggish, still water of large rivers, oxbow and flood plain lakes
		Moxostoma anisurum	silver redhorse	N	Yes	June	in main channel of turbid waters in shallow water, on gravel-rubble bottom	shallows, slow current, sand to gravel bottom, under protection of overhanging banks	turbid river, bottom, slow to moderate current, gravel preferred mud, clay, avoids heavy silt and sedimentation
		Moxostoma erytrurum	golden redhorse	N	Yes	mid-May	in riffles in the main stream	slow-moving streams with soft bottoms	clear streams where riffles are composed of sand, gravel, boulders, bedrock; pools free of vegetation and silt
		Moxostoma macrolepidotum	shorthead redhorse	N	Yes	May - June (1)	on gravel and sand bars, fast riffles in tributary or main channel	gravel shoals along shore in strong current	rivers, not tolerant of heavy silt, bottom, sand gravel substrate
Siluriformes		*Ameiurus melas*	black bullhead	N	Yes	probably June in Manitoba (1)	moderate to heavy vegetation, shallow water	quiet, weedy shorelines and tributaries	bottom, in marginal waters, still to slow current; sand, silt, mud substrate; back waters of larger rivers
		Ameiurus nebulosus	brown bullhead	N	Yes	probably June in Manitoba (KWS)	mud, sand bottom among aquatic roots near cover		bottom in shallow, warm water situations; larger slow-moving streams with abundant aquatic vegetation; sand to mud bottoms
		Ictalurus punctatus	channel catfish	N	Yes	late June-early July (1)	under rocks, logs, cut banks in creeks	margins of main channel in moderate current	cool, clear deep water with sand, gravel, or rubble bottoms
		Noturus flavus	stonecat	N	Yes	June (1)	streams or shallow, rocky areas of lakes		riffles, rapids of moderate or large streams, bottom of loose rocks
		Noturus gyrinnus	tadpole madtom	N	Yes (rare)	July (1)	nests in cavities under logs and stones	dense weed beds on mud or gravel	bottom, still to slow current, soft muddy, weedy substrate with cover
Esociformes	Esocidae	*Esox lucius*	northern pike	N	Yes	April - early May	weedy margins of river channels, pools, backwaters, tributaries	weedy margins of river channels, pools, backwaters, tributaries	mid-water to surface in slow current, variety of substrates, often weedy

FISH SPECIES OF THE RED RIVER				STATUS		SPAWNING		Habitat	
Order	Family	Scientific Name	Common name	KWS*	MAIN CHANNEL	Time	Habitat	JUVENILE	ADULT
	Umbridae	*Umbra limi*	central mudminnow	N	No (or rare)	May-June (1)	marginal waters and tributaries in weeds	marginal waters and tributaries in weeds	surface to bottom in marginal shallows, still to slow current, usually mud substrate, with cover
Osmeriformes	Osmeridae	*Osmerus mordax*	rainbow smelt	I lower reach, 1 record	Yes	probably May-early June in MB (KWS)			
Salmoniformes	Salmonidae	*Coregonus artedi*	cisco	N, lower	Yes	probably October-early November in MB (KWS)	in inland lakes; spawning takes place when ice formed on shores in shallow water over any kind of bottom, often gravel or stony substrate		pelagic species, schooling in midwaters with depth dependant on water temperatures; general movement in spring from shallow to deeper waters and return in fall as upper water temperatures decrease
		Coregonus clupeaformis	lake whitefish	N, recent	Yes	October in Lk Winnipeg(1)	in shallow water over hard or stoney bottom or sand	shallow inlands waters	colder months spent in shoal waters and shallows to spawn, in warmer month move to deeper waters
		Thymallus arcticus	Artic graylling	I, Fort Whyte Centre	No	N/A	adults migrate to small gravel/rock bottomed tributaries streams; after spawning adults return to lakes or rivers		clear waters of large, cold rivers, rocky creeks, lakes;
		Oncorhynchus clarki lewisi	westslope cutthroat trout	I, Clandeboye Ponds	No	N/A			
		Oncorhynchus mykiss	rainbow trout	I, hatchery escapees	No	N/A	smaller tributaries, beds of fine gravel in riffles above pools	may remain in spawning stream 1-3 years or migrate immediately to lake	stream dwelling: shallow rivers with moderate flow, gravel bottoms, pool-riffle type; lake dwelling: deep cool lakes with shallows and vegetation
		Salmo trutta	brown trout	I	No	N/A			
		Salvelinus alpinus	Arctic char	I, hatchery escapees	No	N/A	over gravel or rocky shoals in lakes, quiet pools in rivers; must be deep to provide protection from winter ice		
		Salvelinus fontinalis	brook trout	I	No	N/A			
Percopsiformes	Percopsidae	*Peropsis omiscomayus*	troutperch	N	Yes	May (1)	sand and gravel bottom in shallow water tributaries		shallow, sometimes turbid streams
Gadiformes	Gadidae	*Lota lota*	burbot	N	Yes	January and February in MB (KWS)	deep water on gravel	rocky shallows, shorelines and tributaries; fast to moderate current	bottom, deeper holes and channels, slow to still current, variety of substrates

FISH SPECIES OF THE RED RIVER				STATUS		SPAWNING		Habitat	
Order	Family	Scientific Name	Common name	KWS*	MAIN CHANNEL	Time	Habitat	JUVENILE	ADULT
Cyprinodontiformes	Fundulidae	*Fundulus diaphanus*	banded killifish	N, I record	Yes	May-August (2)			
Gasterosteiformes	Gasterosteidae	*Culaea inconstans*	brook stickleback	N	Yes (uncommon)	June (1)	shallow waters of weedbeds	quiet, weedy shorelines	clear , cold, densely vegetated waters of small streams; swampy margins of lakes
Perciformes	Percichthyidae	*Morone chrysops*	white bass		Yes	early-mid June (1)			upper layers of water column; prefer clear water to silty/turbid waters
	Centrarchidae	*Ambloplites rupestris*	rock bass	N	Yes (uncommon)	June (2)	nests on sand or gravel; swamps to gravel shoals	litoral to limnetic	bottom, in shallow marginal water, still to moderate current, cover required, logs, weeds or rocks
		Lepomis gibbosus	pumpkinseed	N, Whiteshell; I, Lake Minnewasta	No	Probably June-August in MB (KWS)			
		Lepomis macrochirus	bluegill	N, Red River; I, Whiteshell	No	Probably June-August in MB (KWS)	firm bottom of gravel, sand, mud		shallow, weedy, warm water, heavily vegetated, slow flowing
		Micropterus dolomieu	smallmouth bass	I, recent	Yes	Probably June-July in MB (KWS)			
		Micropterus salmoides	largemouth bass	I, La Salle R and Ft Whyte Pond#1	No	June-August (2)			
		Pomoxis annularis	white crappie	N, Rare	Yes	Probably June and July in MB (KWS)			
		Pomoxis nigromaculatus	black crappie	I? (N in Winnipeg River and Lk Winnipeg)	Yes	Probably June and July in MB (KWS)	colonical nests on sand, gravel, mud substrate in shallow water with vegetation cover		clear, quiet, warm water in areas of low flow; dense vegetation; sandy to mucky bottom
	Percidae	*Etheostoma exile*	Iowa darter	N, tributaries	No	May - early June (1)	shallow, quiet water on bottom organic debris or on fibrous roots under cutbanks		bottom, still to slow current, vegetation, organic debris sand, peat or mixed substrate, intolerant of turbid muddy water
		Etheostoma nigrum	johnny darter	N	Yes	May - June (1)	under rocks, in slow water	sand and gravel in current	bottom in shallow water, moderate to no flow, sand, grave, silt, rubble substrate
		Perca flavescens	yellow perch	N	Yes (Uncommon)	May - early June (1)	shallows of lakes, tributaries in rooted vegetation and debris; over sand, gravel	quiet, weedy, marginal water, shoreline shallows	mid-water to bottom, in and near cover, still to slow current, most substrates
		Perina caprodes	logperch	N	Yes (rare)	early May-late August (1)	sandy inshore shallows		sand, gravel, rocky substrate in swift water
		Percina maculata	blackside darter	N	Yes (rare)	May - June (1)	gravel-bottom pools	utilizes mid-depths; less benthic	quiet regions, medium sized pools, gravelly substrate, prefers clear water

FISH SPECIES OF THE RED RIVER				STATUS		SPAWNING		Habitat	
Order	**Family**	**Scientific Name**	**Common name**	**KWS***	**MAIN CHANNEL**	**Time**	**Habitat**	**JUVENILE**	**ADULT**
		Percina shumardi	river darter	N	Yes	May-early July (1)			large rivers with rubble or boulder strewn gravel bottom; moderate current
		Sander canadensis	sauger	N	Yes	late May - early June (1)	over sand and gravel bars in main current of turbid waters	margins and shallows of main channel	slow to fast water near bottom, variety of substrates
		Sander vitreus	walleye	N	Yes	Late April-late May (1)	riffle areas along shores over gravel substrate in tributaries	weedy shallows near shore	slow water near bottom, variety of substrates
	Sciaenidae	*Aplodinotus grunniens*	freshwater drum	N	Yes	Mid-late June (1)	in open water over bottom	pelagic larvae, juveniles over mud bottom in main channel	bottom of main channel over mud, sand, gravel

* KWS = Dr. Kenneth, W. Stewart, Ichthyologist: N = Native, I = Introduced, R = Rare

Sources: Scott and Crossman 1973; Becker 1983; Stewart and Watkinson 2004; Stewart 2004

(1) - Scott & Crossman (1973)
(2) - Becker (1983)
N/A = not available

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TABLE 6C-2
Bivalves and Snails of the Red River Basin

Bivalves		Snails	
Family Unionidae		Family Viviparidae	*Campeloma decisum (Brown Mystery Snail)
Subfamily Ambleminae	*Amblema plicata (Three Ridge) *Fusconaia flava (Pig Toe) *Quadrula quadrula (Maple Leaf)	Family Valvatidae	Valvata sincera sincera (Ribbed Valve Snail) *Valvata tricarinata (Three-keeled Snail)
Subfamily Anodontinae	*Lasmigona complanata (White Heelsplitter) *Lasmigona compressa (Brook Lasmigona) *Pyganodon grandis (Giant Floater) *Anodontoides ferussacianus (Cylindrical Shell) *Strophitus undulatus (Squawfoot)	Family Hydrobiidae	Cincinnatia cincinnatiensis (Campeloma Spire Snail) *Probythinella lacustris (Flat-ended Spire Snail) *Amnicola limosa (Ordinary Spire Snail) Amnicola walkeri (Small Spire Snail)
Subfamily Lampsilinae	*Lampsilis siliquoidea (Fat Mucket) *Lampsilis Ovata (Pocket Book) *Ligumia recta (Black Sand Shell) *Potamilus alatus (Pink Heelsplitter)	Family Lymaeidae	Fossaria exigua (Gracefull Fossaria) *Fossaria modicella (Modest Fossaria) *Fossaria parva (Amphibious Fossaria) Bakerilymnaea dalli (Small Pond Snail) Pseudosuccinea columella (American Ear Snail) Bulimnea megasoma (Showy Pond Snail) *Lymnae stagnalis (Great Pond Snail) *Stagnicola caperata (Blade Ridge Stagnicola)
Family Sphaeriidae			
Subfamily Spaeriinae	*Sphaerium rhomboideum (Rhomboid fingernail clam) *Sphaerium simile (Grooved Fingernail Clam) *Sphaerium striatinum (Striated Fingernail Clam) *Sphaerium lacustre (Lake Fingernail Clam) Sphaerium partumeium (Swamp Fingernail Clam) *Sphaerium securis (Pond Fingernail Clam) *Sphaerium transversum (Long Fingernail Clam)		
Subfamily Pisidiinae	*Pisidium casertanum (Ubiquitous Pea Clam) *Pisidium compressum (Ridged-beak Pea Clam) Pisidium fallax (River Pea Clam) *Pisidium ferrugineum (Rusty Pea Clam) *Pisidium lilljeborgi (Lilljeborg's Pea Clam) Pisidium milium (Quadrangular Pill Clam) Pisidium mitidum (Shiny Pea Clam) Pisidium rotundatum (Fat Pea Clam) Pisidium subtruncatum (Short-Ended Pea Clam) *Pisidium variabile (Triangular Pea Clam) Pisidium ventricosum (Globular Pea Clam) Pisidium walkeri (Walker's Pea Clam) Pisidium punctatum (Perforated Pea Clam)		

References: Clark 1981; Watson et al. (in Press)
* indicates species believed to be commonly found in the mainstem of the Red River Basin
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Table 6C-3
List of Algal Species Historically Found in the Red River, Manitoba

Taxonomic Group	Algae Species
Chlorophyta	*Actinastrum hantzschia*
	Actinastrum hantzschia f fluviatalis
	Actinastrum hantzschia f. fluviatile
	Actinastrum hantzschii
	Ankyra judayi
	Botryococcus braunii
	Cf Eremosphaeria sp.
	Cf Sphaerocystis schroeteri
	Chlamydomonas sp.
	Chorella sp. or free *Dictyosphaerium* cells
	Closteriopsis longissima
	Closterium aciculare
	Closterium acutum
	Closterium cf *strigosum*
	Closterium kuetzingianum
	Closterium sp.
	Coelastrum asteroides
	Coelastrum microporum
	Coelastrum reticulatum
	Coelastrum subcylindricum
	Coelostrum pseudomicroporum
	Coenococcus cf *fottii*
	Coenococcus planctonicaum
	Collodictyon triciliatum
	Cosmarium sp.
	Crucigenia apiculata
	Crucigenia fenestrata
	Crucigenia quatrata
	Crucigenia tetrapedia
	Crucigenia tetras
	Dictosphaerium ehrenbergianum
	Dictosphaerium pulchellum
	Dictosphaerium sp.
	Dictyosphaerium ehrenbergianum
	Dictyosphaerium primarum
	Dictyosphaerium pulchellum
	Dictyosphaerium sp.
	Didymocystis sp.
	Diplochloris cf *decussata*
	Gloeotilia cf *pelagica*
	Gloeotilia contorta
	Green colonies (tiny)
	Keratococcus sp.
	Kirchnerella contorta
	Koliella cf *tatrae*
	Koliella longiseta
	Koliella planktonica
	Lageheimia wratislaviense
	Lagerheimia genevensis
	Monoraphidium cf *flexosum*
	Monoraphidium contortum
	Monoraphidium flexosum
	Monoraphidium griffithii

Taxonomic Group	Algae Species
	Monoraphidium komarkovae
	Monoraphidium minutum
	Monoraphidium setigera
	Monoraphidium tortile
	Nephrochlamy sp.
	Ooccystis lacustris
	oocpar 5.6 2 4
	oocpar 5.6 2.8 12
	oocpar 5.6 2.8 4
	oocpar 5.6 2.8 4
	oocpar 5.6 2.8 6
	oocpar 5.6 2.8 8
	oocpar 5.6 4.2 4
	Oocystis cf *parva*
	Oocystis borgei
	Oocystis lacustris
	Oocystis solitaria
	Oocystis sp.
	Oocystis submarina
	Pediastrum boryanum
	Pediastrum duplex
	Pediastrum simplex
	Pediastrum tetras
	Phacotus cf *lenticularis*
	Planktonema lauterbornii
	Polytomella (colorless flagellate)
	Pteridomonas sp.
	Radiococcus nimbatus
	Scenedesmus acuminatus
	Scenedesmus arcuatus
	Scenedesmus cf *opoliense*
	Scenedesmus cf *serratus*
	Scenedesmus disciformis
	Scenedesmus quadricauda (type)
	Scenedesmus semiparvus
	Scenedesmus sp.
	Schroedaria setigera
	Scorfeldia cf cordiformis
	Small greens *(choricystis, Dictyospharium* cells)
	Staurastrum cf *anatinium*
	Staurastrum triangularis
	Tetraedron caudatum
	Tetraedron minimum
	Tetraedron trigonum
	Tetrastrum staurogeniaformis
	Treubaria triappendiculata
	u-greens *(Choricystis* etc. spp.*)*
	Wornichinia klingii
	Bicoeca sp.
	Dinobryon sociale
	Mallomonas sp.
	Microcystis sp.
	Ochromonas sp.
	Small chrysophytes *(C. parva* and/or *Ochromonads)*
	Synura sp.
	Chroomonas cf *acuta*
	Crptomonas sp.

Taxonomic Group	Algae Species
	Cryptomonas erosa
	Cryptomonas marssonii
	Cryptomonas obovata
	Cryptomonas ovata
	Cryptomonas reflexa
	Cryptomonas rostratiformis
	Cryptomonas sp.
	Gonyostomen semens
	Katablepharis ovalis
	Rhodomonas lacustris
	Rhodomonas lens
	Rhodomonas minuta
Cyanobacteria	*Anabaena akinete*
	Anabaena circinalis
	Anabaena compacta
	Anabaena flos aquae
	Anabaena mendotae
	Anabaena sp.
	Anabaenopsis arnoldii
	Anabaenopsis elenkenii
	Aphanizomenon akinete
	Aphanizomenon aphanizomenoides
	Aphanizomenon cf *gracile*
	Aphanizomenon flos aquae
	Aphanizomenon issatchenkoi
	Aphanizomenon sp.
	Aphanocapsa delicatissima
	Aphanocapsa elachista
	Aphanothece nidulans
	cf *Tychonema rhodonema*
	Chroococcus minutus
	Coelosphaerium subarcticum
	Filamentous bluegreens
	Heterocyte Anabaena
	Heterocyte Aphanizomenon
	Komvophoron sp.
	Limnothrix redekei
	Merismopedia tenuissima
	Microcystis aeruginosa
	Microcystis flos aquae
	Microcystis incerta
	Microcystis incerta (Aphanocapsa incerta)
	Microcystis smithi
	Oscillatoria sp.
	Planktolyngbya contorta
	Planktolyngbya limnetica
	Planktosphaeria suspensa
	Planktothrix suspensa
	Pseudoanabaena contorta (working name)
	Pseudoanabaena limnetica
	Pseudoanabaena sp.
	Small bluegreens
	Snowella cf *lacustris*
	Snowella littoralis
	Snowella sp. (probably lacustris)
	Spirulina sp.
	Synechococcus sp.

Taxonomic Group	Algae Species
	Tiny bluegreens
	u-bluegreens
	Worinichinia cf *ruziska /compacta*
	Woronichinia cf *ruziska/compacta*
Diatoms	*Amphora* cf *ovalis*
	Asterionella formosa
	Aulacoseira ambigua
	Aulacoseira granulata
	Cocconeis placentula
	Cocconeis sp.
	Cyclotella meneghiniana
	Cyclotella meneghininana
	Cyclotella sp.
	Cymatopleura solea
	Diatoma elongatum
	Diatoma vulgaris
	Fragilaria cf *capucina*
	Fragilaria crotenensis
	Gyrosigma acuminatum
	Gyrosigma attenuatum
	Melosira varians
	Navicula cf *gregaria*
	Navicula cf *cryptonella*
	Navicula cf *phyllepeta*
	Navicula sp.
	Nitzschia cf *sigma*
	Nitzschia acicularis
	Nitzschia cf *apiculata*
	Nitzschia cf *coccaeformis*
	Nitzschia cf *cocconieformis*
	Nitzschia cf *graciliformis*
	Nitzschia cf *heufleuriana*
	Nitzschia cf *hungarica*
	Nitzschia cf *palae/palaceae*
	Nitzschia cf *sigma*
	Nitzschia closterium f longissima
	Nitzschia palaceae
	Nitzschia palea
	Nitzschia sp.
	Nitzschia sp. *(tryboniella)*
	Nitztschia acicularis
	Nizschia apiculata
	Nizschia cf *gracile*
	Nizschia cf *sigma*
	Nizschia cf *trybloniella*
	Nizschia gisela
	Rhizosolenia eriense
	Rhizosolenia longiseta
	Skeletonema potamos
	Stephanodiscus & Cyclotella spp.
	Stephanodiscus cf *agassizensis*
	Stephanodiscus cf *hantzschia*
	Stephanodiscus niagarae
	Stephanodiscus sp.
	Surirella cf *ovata*
	Surirella angustata
	Surirella cf *brebissoni*

Taxonomic Group	Algae Species
	Synedra ulna v danica
	Synedra/Nitzschia
	Tabellaria fenestrata
Euglenophyta	*Astasia* sp.
	Euglena acus
	Euglena sp.
	Lepocinclis sp.
	Peranema
	Phacus sp
	Strobomonas sp
	Trachelomonas cf hispida
	Trachelomonas sp
	Trachelomonas volvocina
Pericyta	*Amphidinium* sp.
	Glenodinium cf edax
	Glenodinium sp.
	Glenodinium sp. 2
	Glenodinium sp. 3
	Gymnodinium sp. 1
	Gymnodinium sp. 4
	Peridinium aciculiferum
	Peridinium inconspicuum
Group	**Non- Algal Unicellular Species**
Protozoa	*Amoeba* sp.
	cf *Tintinnids*
	Ciliate
	Codonella cratera
	colorless flagellate
	Didinium sp.
	Haltaria sp.
	Heliozoan
	Scuticociliates
	Strobilidium sp.
	Strombidium sp.
	Thecata amoeba
	Urotrichia sp.
	Vorticella sp.
Rotifers	*Keratella* sp.
	Rotifers
	Trichocerca sp.

Source: Unpublished Raw Data in support of TetrES 2001

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APPENDIX 6D

Aquatic Field Studies

APPENDIX 6D
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1.0 INTRODUCTION

Aquatic field studies were initiated in 2003 to address data gaps with respect to baseline information in support of the assessment of impacts to the aquatic environment resulting from the Red River Floodway Expansion Project.

Baseline aquatic field studies were focused on those aquatic habitats potentially affected by Project construction and operation activities. Areas where aquatic field studies were conducted included:

- the existing Floodway Channel;
- the Red River approximately 2 km downstream and 1 km upstream of the Floodway Outlet Structure at Lockport; and
- drainage ditches along the existing and proposed expanded West Dyke.

Section 2.1, Table 6D-1 lists the aquatic baseline field studies conducted in support of the Red River Floodway Expansion Project Environmental Impact Statement (EIS).

To minimize effects to the aquatic environment, baseline aquatic field studies were conducted using non-invasive / disruptive methods whenever possible (Sections 2.1, 3.1, and 4.1).

2.0 FLOODWAY CHANNEL

A review of the historical dataset found in previous studies that had been conducted regarding the aquatic habitat and communities that exist along the Floodway Channel had not been previously studied. Therefore field studies were required to characterize aquatic habitat and the presence of aquatic communities within the Floodway Channel.

2.1 METHODS

2.1.1 Aquatic Habitat Description

Aquatic habitat along the Floodway Channel was assessed during the fall of 2003 and winter of 2004 (Table 6D-1). In September 2004, a Global Positioning System (GPS) linked video of the Floodway Channel was obtained during a helicopter overflight. This was used to develop a terrestrial and aquatic habitat map of the area. During the field studies in the Fall of 2003, the aquatic habitat was documented at the Floodway Outlet and at representative habitats along the length of the Floodway Channel with emphasis on bridge crossings (Table 6D-2). Locations of each site visited were recorded using a Garmin 12XL (GPS) unit. Photographs and notes were taken documenting the Floodway Low Flow Channel bottom substrate, channel depth, channel width, bank characteristics and extent of aquatic vegetation.

Snowmobiles were used to travel the length of the Floodway Channel during the winter of 2003/04 (on February 4, 2004) to determine if open water areas occur along the Floodway Channel during winter. Locations of open water (or open water under thin ice) were recorded using a Garmin 12XL GPS unit

(Table 6D-3). Where ice conditions allowed, information recorded at each open water site included the approximate area of open water, bottom substrate, water depth, water pH and conductivity.

TABLE 6D-1

AQUATIC BASELINE FIELD STUDIES CONDUCTED FOR THE FLOODWAY EXPANSION PROJECT

Task	Date(s)	Location(s)
Helicopter overflight of the aquatic study area to provide overview of aquatic habitat	Sept. 19, 2003	Floodway including Floodway Inlet, and Outlet areas 1km upstream and 2 km downstream along the Red River
Red River bathymetry studies	Sept. 23, 25 & Nov. 4, 2003	In Red River 1km upstream and 2 km downstream of the Floodway Outlet Structure
Aquatic habitat characterization along Floodway	Sept. 25 & 30, Oct. 2, 3 & 7, 2003 and Feb. 4, 2004	Along the length of the Floodway Channel during open-water season and during winter
Fish Sampling in Red River	Sept. 23 & 25, 2003	Near shoreline up to 100m downstream of Floodway Outlet Structure
Fish Sampling in Floodway	Sept. 30, Oct. 2 & 7, 2003 and March 18, 2004	In the vicinity of the Floodway Outlet Structure and upstream of the Outlet structure within representative habitats along the Floodway Channel
Aquatic habitat characterization and fish sampling at representative drainage channels intersecting the West Dyke	June 6, 2004	At four main drainage channels that intersect the West Dyke

Note: Fish movement studies in the Red River at the Floodway Inlet Control Structure were also conducted during April 2004 to address concerns raised by the Department of Fisheries and Oceans (results of these studies to be reported in a supplemental document)

TABLE 6D-2
CHANNEL DESCRIPTION AT WINNIPEG FLOODWAY CHANNEL SITES VISITED

Location			Date (2003)	Channel Description						
General Description	UTM Easting	UTM Northing		Bottom Substrate	Channel Depth* (m)	Channel Width* (m)	Bank Description	Emergent Vegetation		Submergent Vegetation
								% Cover within Channel	Description Notes	
Outlet Area	647720	5550710	25-Sep	gravel, large cobble & boulder	2	20	Virtually no slope to bank: gravel & cobble all along bank for up to 4 m	10% (due to flooded terrestrial plants)	Terrestrial plants flooded by recent rains ~8m either side of channel	none
PTH 44 Brdg	648300	5550250	25-Sep	gravel, large cobble & boulder	1.5	15	Virtually no slope to bank: gravel & cobble all along bank for 1 to 2 m	none		none
CNR Pine Falls Brdg	648373	5548932	30-Sep	gravel & cobble				light to none	Terrestrial plants flooded by recent rains: 0.5 to 2m either side of channel	none
Drop Structure (E. Side)	648439	5547921	30-Sep	gravel & cobble				light to none	Terrestrial plants flooded by recent rains: 0.5 to 2m either side of channel	none
Decomissioned Crossing at Rebeck Rd.	648622	5446207	30-Sep	gravel & cobble	0.85	6	Changes to silt/clay mix with some (less) gravel & cobble on either side of old gravel crossing	light to none	Terrestrial vegetation flooded occ. along shore out ~0.30m	none
First Channel Constriction	648550	5545149	2-Oct	gravel & cobble changing to clay			Narrow band of gravel/cobble to the N: wider band of clay to the S with occasional boulder & gravel	none		none
Decomissioned Road	647871	554290	2-Oct	gravel, cobble & occ. boulder: riffles at the crossing			Silt just under gravel/cobble, but no bank slumping	none		none
Shkolny Drain	646374	5542337	2-Oct	silt/clay			Bank ~ 0.5 to1m high ~ 1m from channel edge	none		none
Dunning Crossing	646166	5541975	2-Oct	silt/clay with frequent gravel & occ. cobble	0.95	10.5	Boulder/cobble 40m either side of crossing then turns to clay: at crossing, lots of exposed gravel up to 40m on either side	none		none
Transmission Line (T-line) Crossing	644655	5537759	2-Oct	silt/clay with occ. rock/gravel			Slight bank erosion on both sides	none		none
PTH 59 North Brdg	644454	5536335	2-Oct	gravel with occ. cobble/boulder	0.33	10	Eroding bank (clay/gravel bank 0.5m high)	none		none
Springfield Rd. Drain	644918	5535477	2-Oct	silt/clay	~1m	10	Silt, no cobbles or gravel	none		none
T-line Crossing	644715	5535605	2-Oct	silt/clay, gravel			Eroding silt/gravel shoreline: bank 0.5m high	none		none
CPR-Keewatin Brdg	645860	5532262	3-Oct	silt/clay, gravel with occ. boulder	~1m	10		none		none to light *Potamogeton* sp. patches
Kildare Drain (W Side) & Drop Structure (E Side)	646738	5529779	3-Oct	silt/clay with occ. boulder		9		none		none
CNR-Reddit Brdg & PTH 15 Brdg	646894	5527974	3-Oct	silt/claly with occ. gravel		18 to 20	Silt with occ. gravel: same for both bridges	none		none
Drop Structure (E Side)	646886	5526336	3-Oct	silt/clay	~1m	15 to 20	1m high bank of eroding clay	none		none
GWWD Rail Brdg at Deacon Reservoir	646932	5524259	3-Oct	silt/clay	~1m	18 to 20	0.5m high eroding bank is clay mixed with cobble	none		none
Hwy #1 Brdg	646908	5522021	3-Oct	silt/clay		18 to 20	1m high eroding bank	none		none
CNR-Sprague Brdg	646787	5521673	3-Oct	silt/clay		15 to 18	Eroding bank, 1:2 slope at bank edge	none		none
PTH 59 South Brdg	641221	5517679	3-Oct	silt/claly, gravel		8 under brdg, N. of brdg 4 to 6	Occasional gravel, same for both bridges	10-80%	Cattails rare to occ.: bulrushes dominant	none
Seine River Syphon	640756	5517151	7-Oct	silt/clay	0.41	4	At outflow 1st 15m is boulder/ rock then turns to silt/clay	50-90%	Bulrush dominant	none
CPR-Emerson Brdg	640374	5516815	7-Oct	silt/clay	~0.5	15	Clay with various man-made debris	10 to 20% at brdg, 60% beyond 50m S of brdg, 80% beyond 50m N of brdg	Bulrushes within 50m on either side of bridge	none
St. Mary's Rd. Brdg	635411	5513269	7-Oct	silt/clay	~0.5	4	Eroding bank, slope 1:2	none		few dead

* Channel width and depth are estimates provided primarily at sites where fish sampling occurred (note that channel depth and width can change substantially with rainfall events, season, etc.)

Note that water chemistry descriptions are provided for sites where fish sampling occurred (see Table 6D-6)

TABLE 6D-3

WINTER OPEN WATER AREAS ALONG FLOODWAY CHANNEL, FEB. 4, 2004

Location				Potential Refugia Description						
General Description	Wpt	UTM Easting	UTM Northing	Area of Observable Thin Ice Cover over Open Water	Open water Area	Water Depth (m)	pH (Units)	Cond. (μs)	Bottom Substrate	Notes
Near Shkolney Drain area	3	647478	5543606	9m long x 4m wide	4m long x 2m wide	at least 0.3	7.3	1520	-	Water percolating up; is part of a narrow stream heading west into willows (stream has open water also)
Near Shkolney Drain area	4	647384	5543493	4m x 3m	0.5m x 0.5m	-	-	-	-	Thin ice too unsafe to get water chemistry measurements etc.; water percolating up
Dunning Crossing* (NE of crossing about 20m downstream	-	Too cold for GPS		Extensive (typically 0.5 to 1m wide x several metres long in areas mostly along NW edge of channel)	Broke through thin ice to take measurements	0.13	7.1	1560	cobble/ gravel	Flowing water visible (~0.5m/sec)
Just before channel bends directly south, ~1.2 km SW of Coronation Rd. and ~2.6 km SW of Dunning Crossing	5	644653	5539961	4m x 1m	Broke through thin ice to take measurements	0.2	7.3	1520	Silt with occasional cobble	Water bugs active; flow observable
~ 3 km SW of Dunning Crossing	6	644511	5539627	100m x 0.5m	Broke through thin ice to take measurements	0.3	7.3	1550	-	Observable slow flow
North side of North Hwy 59 Brdg at Spring Hill**	-	~ 644650	~ 5536900	5m x 1.5m & several 0.5m x 0.5m areas	Frozen over but open water under ice is likely	-	-	-	-	
~3.1 km S. of North Hwy 59 brdg.	7	645495	5533497	4m x 1m	Frozen over but open water under ice is likely	-	-	-	-	Likely a narrow 'ditch' of water under ice on west side of channel: snowmobiles recently punched through ice that is now frozen-over again
~3.8 km S. of North Hwy 59 brdg.	8	645578	5533291	75m x 0.5m	1m x 0.5	-	-	-	-	Thin ice/open water is on west side of channel (camera frozen, unable to take pictures)
~4 km S. of North Hwy 59 brdg.	9	645675	5533029	15m x 2m	3m x 0.5m	-	-	-	-	Water percolating up at west shore of channel
~4 km S. of North Hwy 59 brdg.	10	645689	5532994	-	0.5m x 0.5m	0.2m	-	-	Cobble/ weed/silt	Appears to be drainage trickling into channel; both sides of channel are ice covered but were probably open recently

TABLE 6D-3 Cont.

Location					Potential Refugia Description					
General Description	Wpt	UTM Easting	UTM Northing	Area of Observable Thin Ice Cover over Open Water	Open water Area	Water Depth (m)	PH (units)	Cond. (µs)	Bottom Substrate	Notes
~4 km S. of North Hwy 59 brdg.	11	645698	5532966	30m x 1m	2.5m x 1m	-	-	-	-	
~550m N. of CPR-Keewatin rail brdg.	12	645726	5532891	10m x 0.5m	0.15m x 0.15m	-	-	-	-	Along east bank of channel
~500m N. of CPR-Keewatin rail brdg.	13	645734	5532858	20m x 0.5m	0.5m x 0.5m	-	-	-	-	Along west bank of channel
~350m N. of CPR-Keewatin rail brdg.	14	645823	5532632	50m x 0.5m	Frozen over but open water under ice is likely	-	-	-	-	
~175m N. of CPR-Keewatin rail brdg.	15	645879	5532482	-	0.5m x 0.5m	-	-	-	-	Deer watering hole (tracks leading to/from)
~275m S. of CPR-Keewatin rail brdg.	16	646039	5532060	11m x 3m	Frozen over but open water under ice is likely	-	-	-	-	Along west bank of channel
~350m S. of CPR-Keewatin rail brdg.	17	646068	5531974	12m x 0.5m	3m x 0.5m	0.2	-	-	silt/cobble/ weed	Channel appears to go under snow and into willows on west side of channel
~1.4 km S. of CPR-Keewatin rail brdg.	18	646440	5530943	0.3m x 0.3m	Frozen over but open water under ice is likely	-	-	-	-	Another deer watering hole
~1.65 km N. of CNR Reddit Brdg	19	646878	5529782	-	several metres wide stretching up channel in distance	-	-	-	-	Danger thin ice signs: trail diverted off channel to west slope
~1.2 km N. of CNR Reddit Brdg	20	646825	5529356	-	20m x 5m	-	-	-	-	Traveled off channel on west slope due to thin ice
At base of CNR Reddit Brdg		~647000	~552815 0	-	2m x 1m	-	-	-	-	Open water at both east and west brdg pilings
By Deacon Reservoir: ~250m south of GWWD rail brdg.	21	647099	5524096	-	10m x 0.75m	-	-	-	-	Flowing water visible: drain visible nearby: road width clearing between brdg and waypoint, almost up to channel (prep. for groundwater drilling?)
~1.15 km south of GWWD rail brdg.	22	647124	5523220	25m x 2m	7m x 2m	-	-	-	-	Along west bank of channel: about 200m from another road clearing with 2 drilling trucks under transmission line
~400m N. of Hwy#1 Brdg.	23	647147	5522284	-	-	0.2	-	-	cobble	Many water bugs present

TABLE 6D-3 Cont.

Location					Potential Refugia Description					
General Description	Wpt	UTM Easting	UTM Northing	Area of Observable Thin Ice Cover over Open Water	Open water Area	Water Depth (m)	PH (units)	Cond. (μs)	Bottom Substrate	Notes
~300m N. of Hwy#1 Brdg.	24	647139	5522191	-	0.5m x 0.5m	1	-	-	Silt with occasional cobble	Muskrat trail leading to / from open water: bubbles percolating up from substrate (east bank)
Seine R. Siphon area		~640775	~5517200	-	Width of channel (~20m wide) extending upstream & out of sight	-	-	-	-	Could not travel along floodway channel upstream of this point for several kms, after several kms, no more open water areas were obvious

*Visited Feb. 3, 2003

**Snowmobile trail diverted from the channel to the Floodway slope South of the N. Hwy 59 brdg for about 3km before diverting back to the channel, therefore there likely are abundant areas of thin ice and open water under ice in that area

Notes:

Thin ice at most potential refugia made taking water measurements (depth, pH, conductivity) impractical.

Open water at least 2m wide and 1m deep in channel at base of Spring Hill (observation: Feb. 6, 2004, Don Harron, TetrES pers. comm. Feb. 7/04)

General Observation: Areas of open water/thin ice appeared highly correlated with dense willow growth on either side of the channel

2.1.2 Fish Community Assessment

Within the Floodway Low Flow Channel, fish were sampled at the Floodway Outlet (Table 6D-4) and at five other representative aquatic habitat locations (Table 6D-5):

- a decommissioned road crossing at Reebeck Road;
- Dunning Road Crossing;
- PTH 59 North Bridge;
- at the Springhill area; and
- at the Seine River Syphon area.

Locations of each fish-sampling site were recorded using a Garmin 12XL GPS unit. At each fish sampling location, the following water characteristics and water chemistry parameters were recorded (Table 6D-6):

- water velocity;
- maximum depth;
- water temperature (near surface, mid-depth and bottom);
- dissolved oxygen (near surface, mid-depth and bottom);
- pH (near surface); and
- conductivity (near surface).

TABLE 6D-4

FISH SAMPLING RESULTS IN FLOODWAY AT OUTLET

Capture Method	Gear Set		Gear Checked		Time Gear Set (hrs)	UTM Location		Bottom Substrate	Water Depth (m)	Distance from Shore (m)	Fish Caught		
	Date (2003)	Time	Date	Time		Northing	Easting				Species	Number	Fork Length (cm)
Lg Hoop Net	Sept. 30	12:00	Oct. 1	15:50	15.75	5550701	647801	Rock/gravel	1.5	8	Trout-perch	1	7
											White Sucker	1	31
											White Sucker	5	17 to 20
											White Sucker	11	14 to 16
Mini Hoop Net	Sept. 30	12:30	Oct. 1	15:45	15.25	5550592	647899	Rock/gravel	0.5	2 to 3	None		
Mini Hoop Net	Sept. 30	12:40	Oct. 1	15:45	15	5550586	647905	Rock/gravel	0.5	2 to 3	None		
Mini Hoop Net	Sept. 30	12:55	Oct. 1	15:40	14.75	5550577	647916	Rock/gravel	0.3	2 to 3	None		
Minnow Trap	Sept. 30	12:35	Oct. 1	15:45	15.25	5550588	647902	Rock/gravel	0.5	2 to 3	None		
Minnow Trap	Sept. 30	12:50	Oct. 1	15:40	14.75	5550584	647910	Rock/gravel	0.3	2 to 3	None		
Minnow Trap	Sept. 30	13:00	Oct. 1	15:40	14.75	5550533	647964	Rock/gravel	0.3	2 to 3	None		

Notes: All fish were kept (frozen for future examination if necessary)

Eight to 10 small bullheads (~10 to 13 cm in length) were observed swimming out from rocks and emergent/submergent vegetation cover within 2 metres of shore during net sets on Sept. 30/2003.

See Table 6D-6 for water chemisty on Sept. 30 and Oct. 1, 2003

TABLE 6D-5

FISH SAMPLING RESULTS IN THE FLOODWAY AT SITES UPSTREAM OF THE OUTLET AREA

Location			Date	Time	Seine Net Pulls		Bottom Substrate	Water Depth (m)	Fish Caught		Notes
General Description	UTM Northing	UTM Easting			Length of Net (m)	Distance Pulled (m)			Species	Number	
Decomissioned Crossing at Rebeck Rd.	5446207	648622	30-Sep-03	16:07	6	4 X10m	gravel & cobble	0.85	White Sucker	1	16.5cm length
									White Sucker	2	8 to 10cm length
									White Sucker	2	6.5cm length
									Black-sided Darter	2	Adult
									Johnny Darter	1	Adult
									Fathead Minnow	1	
Dunning Crossing	5541975	646166	2-Oct-03	11:21	6,7,7 &3	7,7,7 & 12m	silt/clay with frequent gravel & occ. cobble	0.95	Fathead Minnow	1	Adult
									Fathead Minnow	5	Young-of-year
									Johnny Darter	1	
									Northern Pike	1	19cm fork length
									White Sucker	19	Young-of-year
	5542001	646228	18-Mar-04	13:36	2*	2 X 10m*	gravel/cobble/ sand	0.4	None	–	Although no fish were caught, several dead fish of various sizes/species were observed: See **Table 6D-7.** Additionally, two whole dead crayfish were observed in stream, and one live *Dytiscus* sp. (predaceous diving beetle) with egg mass
PTH 59 North Brdg	5536335	644454	2-Oct-03	11:50	6	35	gravel with occ. cobble/boulder	0.33	Fathead Minnow	5	Very clear water
									White Sucker	11	Young-of-year
									Johnny Darter	3	
									very small minnows	6	Young-of-year: would need microscope to identify
Springhill	5536637	644561	18-Mar-04	11:07	2	2 X 10m	gravel/cobble/ some silt	0.05 - 0.4	None	–	Although no fish were caught, many dead fish of various sizes /species were observed: See **Table 6D-7**
Seine River Syphon	5517151	640756	7-Oct-03	9:25	6	3 X 6m	gravel & silt/clay with occ. boulder	0.2	Fathead Minnow	2	Fish were caught in the Seine R. Diversion Channel by the confuence with the Floodway Channel, primarily in riffle/pool habitat. Water was flowing through all 4 culverts. Silty substrate in the Floodway Channel hampered seining efforts there.
									Trout-perch	1	
									Johnny Darter	1	

*Additionally, five round cage-style minnow traps baited with dry catfood kibble were set for 24 hrs (one in SE culvert at 63cm depth, one 3m downstream of SE culvert at 20cm depth and three others ~ 30m downstream of culverts at 20cm depth). No live fish were caught.

TABLE 6D-6

WATER CHARACTERISTICS IN FLOODWAY AT FISH SAMPLING SITES

Date (2003 - 2004)	Time	Location			Max. Depth (m)	Water Velocity (m/sec)	Water Chemistry							
							Surface				Mid-Depth		Bottom	
		General Description	UTM Northing	UTM Easting			Temp. (°C)	Dissolved Oxygen (ppm)	PH (Units)	Cond. (µs)	Temp. (°C)	Dissolved Oxygen (ppm)	Temp. (°C)	Dissolved Oxygen (ppm)
Sept. 30	12:00	Floodway at Outlet	5550701	647801	1.5	-	6.5	12.8	8.2	920 *	6.5	12.7	6.5	12.6
Oct. 1	15:00	Floodway at Outlet	5550333	647964	1.2	0 at 0.5m	8.0	12.8	8.3	1000	7.4	13.8	7.8	13.5
Oct.1	17:50	Decomissioned Crossing at Rebeck Rd.	5446207	648622	0.85	None 0.74 at 0.1m 0.8 at 0.25m	7.7	12.6	8.6	830*	7.6	12.9	7.6	12.8
Oct. 2	11:12	Double Culvert at Dunning Crossing	5541975	646166	~1.5	4.0 at 0.3m	-	-	-	-	-	-	-	-
					~1.5	2.3 at 0.5m	-	-	-	-	-	-	-	-
Oct. 2	11:12	Dunning Crossing	5541975	646166	0.95	0.38 at 0.5m	7.1	11.7	8.3	1250	6.6	11.8	6.5	11.7
Oct. 2	11:50	PTH 59 North Brdg	5536335	644454	0.33	2 at 0.15m	-	-	8.5	900	8.2	13.8	-	-
Oct. 7	9:25	Seine River Syphon: in Seine R. diversion outflow from culverts at confuence with Floodway Channel	5517151	640756	0.14 in culverts: 0.2 in Seine diversion ouflow	5.4 at 0.09m in culvert: 2.3 at 0.1m in Seine diversion outflow	-	-	8.1	500	11.8	10.1	-	-
Oct. 7	9:25	Floodway Channel at confluence with Seine R. diversion outflow	5517183	640729	0.41	0	11.9	10.4	8.1	500	11.3	10.6	-	-
March 18	11:07	Spring Hill: in Floodway Channel at base of Spring Hill	5536637	644561	0.4	estim.~ 0.2	-	-	7.7	1510	3.2**	10.3**	-	-
March 18	13:36	Dunning Crossing: SW side of culverts	5541963	646213	0.3	0.75 through culverts	1.3**	10.2**	7.7	1450	1.3**	10.3**	1.3**	10.3**
July 19	14:46	6m upstream of riffle area between Floodway Outlet and PTH 44 Brdg	5550480	648028	0.5				8.2	860	29.2	11.3		
July 19	15:21	Dunning Crossing	5541934	646176	0.5 to 0.75				8.6	860	28.2	11.9		
July 19	15:51	Springhill in Floodway Channel at base of Springhill	5536645	644561	0.1		27.8	9.9	8.3	880				
July 19	17:10	Floodway Channel at confluence with Seine R. diversion outflow	5517173	640713	0.1		32.0	10.6	8.4	700				

* Old conductivity meter (measurements may be low by 100 to 150 µs). For all other measurements, a new conductivity meter was used.

** Water temperature and Dissolved oxygen measurements taken the next day when ambient air temperatures were above zero

2.1.2.1 Fall 2003 Fish Sampling

In the Floodway Channel at the Floodway Outlet Structure, fish were sampled September 30 / October 1, 2003 using one over-night set of three folding minnow traps, three mini hoop/fyke nets and one large hoop/fyke net. The mini hoop nets were 3 metres long, 25cm in diameter with 5cm entrance holes and 1/4" mesh. The large hoop net was 3.65 metres long with two 7.6 metre-long corral wings, 76cm hoops with 5cm and 10cm entrance holes.

At the five fish sampling sites in the Floodway Channel upstream of the Floodway Outlet, seine nets were used to sample fish due to the shallow water present (0.05 to 0.85 metres).

2.1.2.2 Winter 2004 Fish Sampling

Fish sampling occurred at two of the largest open water areas along the Floodway Channel on March 18, 2004: at Dunning Road Crossing and in the Spring Hill area (Table 6D-7). The same water characteristics and chemistry was recorded as at fish sampling sites during fall 2003 (Section 2.1.2.1; Table 6D-6). At each of the two sampling sites, dead fish were observed and recorded (Table 6D-7). Seine net pulls at both sites and one over-night set of four cage-type minnow traps (baited with dry cat food kibble) at the Dunning Crossing site were conducted. Minnow traps were not set at the Spring Hill area due to insufficient water depth.

2.1.2.3 Summer 2004 Fish Habitat Reconnaissance

Reconnaissance surveys along the Floodway Channel will also occurred on July 19, 2004 during a period of three consecutive days of high ambient temperatures (30^{o} c or higher) to determine if fish kills occur due to high water temperatures resulting in lethally low dissolved oxygen. Water temperature, dissolved oxygen, pH and conductivity were recorded at four of the five sites visited along the Floodway Channel where possible evidence of fish kill were most likely to occur (Table 6D-6). The sites investigated for evidence of potential Summer Fish Kill included:

- The Floodway Outlet Area;
- Between the Floodway Outlet and PTH 44 Bridge;
- Dunning Crossing;
- Springhill area; and
- Seine River Siphon area

TABLE 6D-7
WINTER-KILLED FISH OBSERVED IN THE FLOODWAY AT TWO OPEN-WATER SITES UPSTREAM OF THE OUTLET AREA

Location			Date	Time	Length x avg. Width of Open Water Channel where Dead Fish were Observed*	Dead Fish Observed			Notes
General Description	UTM Northing	UTM Easting				Species	Length**	Number	
Dunning Crossing	5542001	646228	18-Mar-04	13:36	16m x 2m	White Sucker	0.30 to 0.45m	2	Most fish were in good to excellent condition (little decay evident) with no evidence of scavenging on all but 2 or 3 fish: most fish partly frozen into ice
							<0.30m	2	
						Yellow Perch	0.18 & 0.20m	2	
						Tadpole Madtom	0.06	1	
Spring Hill***	5536637	644561	18-Mar-04	11:07	100m x 3m (this was the area searched, but open water extended further south by more than 100m and further north by approx. 50 m)	White Sucker	>0.45m	3	Two whole dead crayfish and one live *Dytiscus* sp. (predaceous diving beetle) with egg mass were also observed: dead fish were whole (expect one perch) and typically in good condition (little decay evident): most fish not frozen into ice but were lying in shallow water (< 20cm depth)
							0.30 to 0.45m	4	
							<0.30m	10	
						Northern Pike	>0.45m	5	
							0.30 to 0.45m	4	
							<0.30m	5	
						Yellow Perch	0.15	3	
						Blackside Darter	0.08	3	
						Longnose Dace	0.12	1	

*Some fish, particularly small forage fish were difficult to see since some were frozen under ice ledges at edges of channel and small fish were often coated with a fine layer of silt and were difficult to see, therefore dead fish densities were likely greater than recorded in the area searched.

**Maximum total length

***Two additional dead fish <8cm in length were also observed but were decayed beyond recognition at Spring Hill

Note: Vists were made to two other sites considered to have high potential for open-water based on reconnaissance for open-water potenial fish refugia on Feb. 4, 2004, however the other sites (Siene R. syphon area and Shkolney Drain area) were forozen over likley due to wind blowing snow cover off ice

2.2 RESULTS

2.2.1 Aquatic Habitat

2.2.1.1 Fall 2003

During field studies conducted along the Floodway Channel between September 25 and October 7, 2003, water was present and continuous in the Low Flow Channel for the majority of the Floodway length. Isolated ponds and dry channel areas occurred within the southern-most reach of the Floodway between the CPR Emerson Bridge and the St. Mary's Bridge crossings (Photograph 1 and EIS Section 6.4.2.1; Figure 6.4-1). The width of wetted area within the Low Flow Channel varied from 4 to 20 meters with water depth ranging between 0.3 to 2 meters (Table 6D-2). Wetted channel width and depth was greatest immediately upstream of the Floodway Inlet Control Structure. This is likely due to the fact that the Floodway Outlet hydraulic gates of the two culverts were in the closed position, restricting water drainage from the Floodway to the Red River at that time.

Water temperatures in the Floodway Low Flow Channel ranged from 6.5°C on September 30, 2003 to 11.9°C on October 7, 2004 (Table 6D-6). The almost doubling of water temperature in the Floodway Channel occurred as a result of increased ambient air temperatures during that time period. Dissolved oxygen ranged from 10.4 to 12.8 ppm, pH ranged from 8.1 to 8.6 units and conductivity ranged from 500 to 1250 µs.

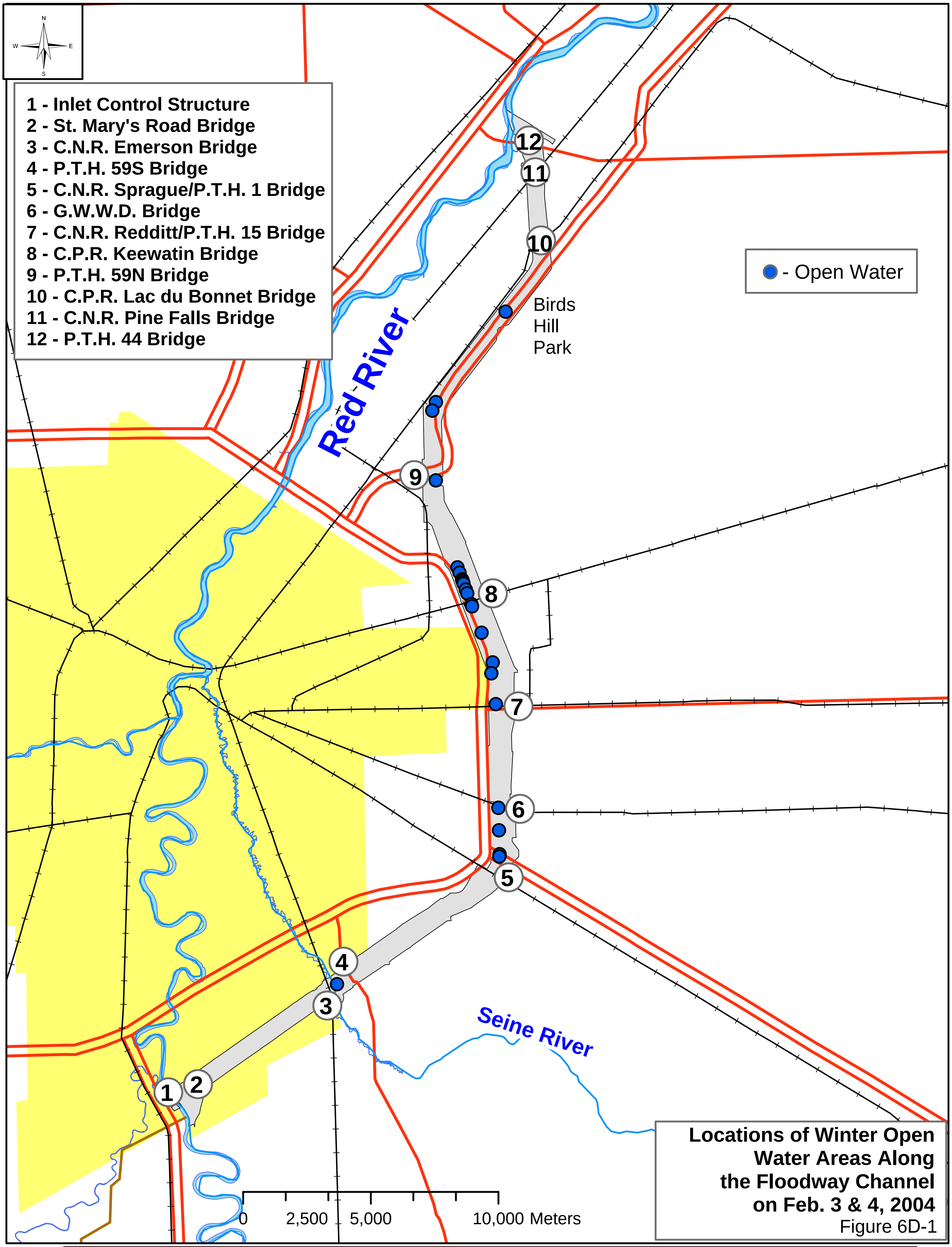
Photograph 1: Example of isolated pond areas observed along the Floodway Channel between the CPR-Emerson Bridge and St. Mary's Road Bridge, October 2003.

Bottom substrate along the majority of the Floodway Low Flow Channel consisted of silt/clay, with gravel and cobble substrate becoming more frequent in the northern third of the Low Flow Channel (Table 6D-2). Bottom substrate was primarily gravel and cobble within the northern 5 km reach up to the Floodway Outlet Structure at Lockport. The short channel section (approximately 100 metres in length) leading from the Floodway Outlet Structure downstream to the Red River consisted primarily of gravel, boulder and cobble bottom substrate.

With the exception of some flooded terrestrial vegetation along the northern-most 4.5 km reach of the Floodway Low Flow Channel, emergent aquatic vegetation was not evident with the exception of a one km reach at the south end of the Floodway between the PTH 59 South Bridge and the CPR-Emerson Bridge where bulrushes were dominant with cattails occasionally observed (Table 6D-2). Vegetation surveys along the Floodway, including aquatic vegetation surveys, are on going during 2004: results will be submitted in a supplemental document.

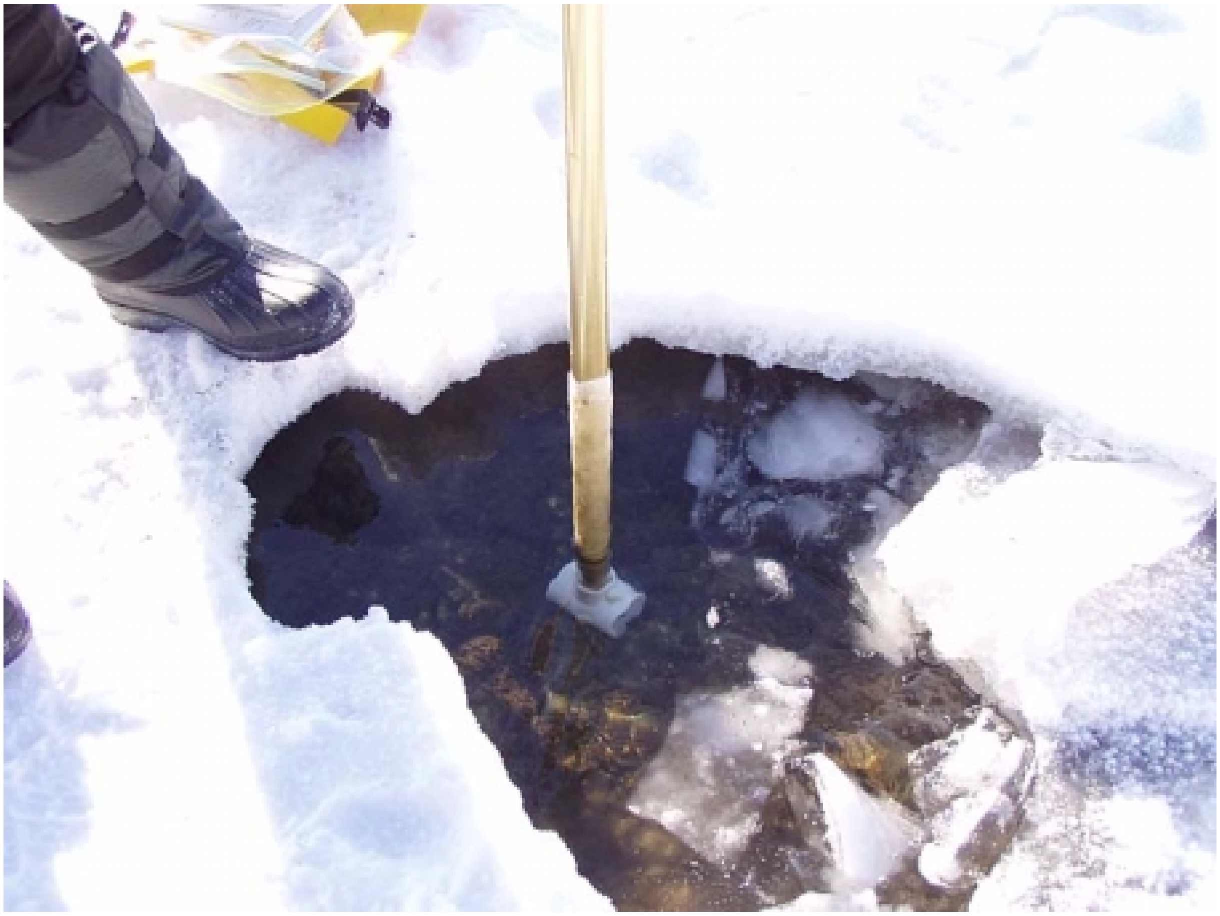
2.2.1.2 Winter 2004

Observations of the entire length of the Floodway Low Flow Channel on February 3 and 4, 2004 indicated that the channel did not freeze to the bottom, probably due to continuous groundwater seepage through the base of the Low Flow Channel (Table 6D-3). Field studies at that time indicated that up to 26 distinct areas of open water or water under thin ice occur along the length of the Floodway Low Flow Channel between the area where the Seine River Syphon overflow intersects the Floodway (approximately 7 km downstream of the south end of the Floodway) to the Shkolny Drain area (approximately 7 km upstream of the Floodway Outlet Structure; Table 6D-3 and Figure 6D-1. The size of the open water areas observed ranged from a minimum of 0.5 metres wide by 0.5 metres long to 20 metres wide by at least 50 meters in length (at the Seine River Syphon overflow area: Table 6D-3). Water depth within the open water areas (at sites where ice cover was safe for taking measurements) ranged from 13 cm to 1 metre (Photograph 2). Water conductivity ranged from 1520 to 1560 µs and pH ranged from 7.1 to 7.3 units (Table 6D-3).



Locations of Winter Open Water Areas Along the Floodway Channel on Feb. 3 & 4, 2004

Figure 6D-1



Photograph 2: Recording water chemistry and characteristics of open water areas along the Floodway Channel during February 2004

On March 18, 2004 two of the largest open water areas along the Floodway Channel were re-visited (for the purpose of sampling fish: Section 2.2.2.2). These open water areas were located at the Spring Hill site and at Dunning Crossing. At the Spring Hill area, the Floodway Channel contained open water for several hundred meters extending north and south from the base of Spring Hill. Water was clear, flowing, had a slight anoxic smell (although dissolved oxygen level was high: 10.3 ppm, on March 19^{th}: Table 6D-6), pH was 7.7 units and conductivity was 1510 µs. Water depth ranged from 5 to 40cm, and substrate was gravel / cobble with some silt (Table 6D-5).

At the Dunning Crossing location on March 18, 2004, open water in the Floodway Channel was observed at the road culverts and in another open water area (16 m long by 0.5 to 2.5 m wide) approximately 20 m south of the road crossing. Water depth was 40cm or slightly shallower or deeper at both open water areas with bottom substrates consisting of gravel, cobble and sand (Table 6D-5). Water was clear, flowing, had a dissolved oxygen level of 10.2 to 10.3 ppm (on March 19^{th}: Table 6D-6), pH was 7.7 units and conductivity was 1450 µs.

2.2.2 Fish Community

2.2.2.1 Fall 2003

Fish sampling efforts in the Floodway Channel at the Floodway Outlet Structure and at five other sites upstream of the Floodway Outlet between September 30 and October 7, 2003 resulted in a total catch of 83 fish representing six species: white sucker, fathead minnow, Johnny darter, black-sided darter, trout-perch and Northern pike (Tables 6D-4 and 6D-5). White sucker was the most common species caught in the Floodway Channel (51% of total catch) with the remaining catch consisting of one Northern Pike and small forage fish species. In addition, eight to 10 small bullhead catfish were observed swimming out from rocks and partly submerged terrestrial vegetation within two metres of the shoreline in the Floodway Channel in the vicinity of the Floodway Outlet Structure. Several of the white suckers and fathead minnows were young of the year. Of the larger fish species caught, most were small (immature) with the largest white sucker having a 31 cm fork length (most less than 17 cm) and the Northern pike having a 19 cm fork length (Tables 6D-4 and 6D-5).

2.2.2.2 Winter 2004

Numerous dead fish were observed in the Floodway Channel at the two open-water sites visited on March 18, 2004 (Table 6D-7), i.e. the Spring Hill area and Dunning Crossing area. At the Spring Hill site, a total of 40 dead fish (of varying age classes) were observed over a 100m length of channel (avg. channel width approx. 2.5 m, Photograph 3). Dead fish observed included some large northern pike and white suckers (> 0.5 m in length). Species observed in order of abundance included: white sucker (n=17), northern pike (14), Yellow perch (3), blackside darter (3), longnose dace (1), and two decomposed (species not readily identifiable in field due to decomposition). Seine netting efforts at this site yielded no live fish.

Photograph 3: Examples of dead fish in Floodway Channel at Springhill, March 18, 2004

At the Dunning Crossing site on March 18, 2004, a total of 7 dead fish were observed in the open-water pool 20m south of the crossing. The dead fish were partly frozen into the ice at the edge of the channel and consisted of 4 white suckers (varying age classes), two yellow perch (18 & 20 cm) and one tadpole madtom. Additionally, two intact dead crayfish were observed. Seine netting efforts and 24hr baited minnow trap sets yielded no live fish at the Dunning Crossing site.

2.2.2.3 Summer 2004

No dead fish were observed in the Floodway Channel at the five locations (Section 2.1.2.3) visited during three consecutive days of hot ambient temperatures (30^{o} c or higher). At the four sites where water chemistry parameters were measured, dissolved oxygen levels were sufficient to support fish (11.9 to 9.9 ppm) and water temperatures ranged from 32 to 27.8^{o} c (Table 6D-6).

Photograph 4: Examples of dead fish in Floodway Channel at Dunning Crossing, March 18, 2004

2.3 DISCUSSION

Although fish do occur in the Floodway Channel, observations of fish kills during winter indicate that the Floodway is not good year-round fish habitat and appears to be a 'population sink' for those fish that are trapped in the floodway over winter. The probability that fish did not over-winter in the floodway channel is high since:

- no live fish were captured using techniques that have yielded fish during the open water season; and
- numerous dead fish were observed in two locations in the Floodway Channel suggesting that extremely low oxygen levels likely occurred at some time during the winter in refugia (open water pockets) along the Floodway Channel.

Additionally, the bank characteristics and bottom structure of the Floodway Low Flow Channel, combined with general lack of extensive aquatic vegetation or in-stream structure (e.g. downed trees, tree roots, etc.) do not provide good escape cover for fish thereby making them potentially more susceptible to predation primarily by larger fish and piscivorous birds and mammals. Results of field reconnaissance studies along the Floodway Channel during July 2004 suggest that water conditions during the hottest days of summer appear to be suitable habitat for fish (i.e., no fish kills were observed furing reconnaissance in July 2004: Section 2.2.2.3.

3.0 RED RIVER

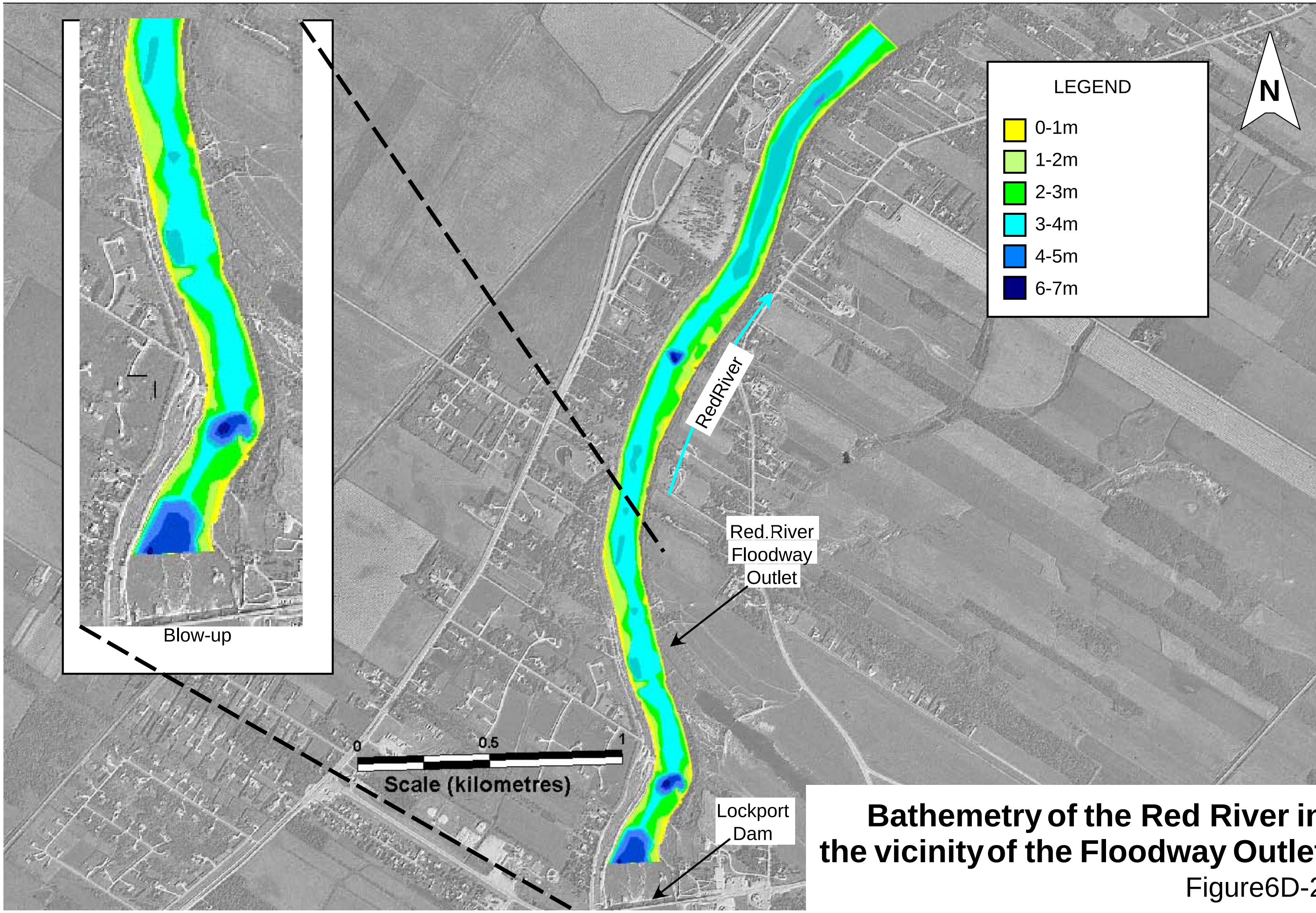
Effects to the Red River aquatic habitat and aquatic community resulting from the Floodway Expansion Project are expected to be limited to those shoreline areas that will be disturbed as a result of construction activities associated with the modification and expansion of the Floodway Outlet Structure and deposition of rip-rap along selected erosion prone banks downstream of the Floodway Outlet Structure. As such, aquatic field studies on the Red River were limited to the area of the Red River approximately 2 km downstream and 1 km upstream of the Floodway Outlet Structure.

3.1 METHODS

3.1.1 Aquatic Habitat Description

To acquire additional information on the aquatic habitat within the Red River, field studies were conducted in the reach 2 km downstream and 1 km upstream of the Floodway Outlet Structure during September and November 2003 (Table 6D-1). These field studies focused on providing detailed information on the river bottom substrate characteristics and bathymetry (bottom depth/contouring). Additionally, the shoreline and upland habitat characteristics were also recorded along both banks of the river within the above-stated reach (Table 6D-8).

Bathymetry studies were conducted using a PCSounder® (a GPS-linked bathymetry sounder) installed on a boat which then zigzagged back and fourth from bank to opposite bank within the reach of the Red River adjacent to the Floodway Outlet Structure (Photograph 5). Bottom depth/contouring information was recorded enroute and processed into a bathymetre map of the area (Figure 6D-2).



Bathemetry of the Red River in the vicinity of the Floodway Outlet
Figure6D-2

bathym_map
ms\01\0211\09

TABLE 6D-8

SHORELINE CHARACTERIZATION OF RED RIVER NEAR FLOODWAY OUTLET

Date (2003)	Location				Upland Substrate	Upland Vegetation	Upland Relief [a]	Shoreline Substrate [b]	Shoreline Vegetaton	Shoreline Relief [a]	Shoreline Woody Debris	Notes	Photo #/ File	Photo Time
	Start Point		End Point											
	UTM Northing	UTM Easting	UTM Northing	UTM Easting										
East Shoreline Upstream (South) of Floodway Outlet														
Sept. 23	5550252	647446	5550354	647487	sand/silt/ organic mix	deciduous & park with mowed grass	1m/50 m	cobble	none	1 m/500 m	occasional beached	Traveling approx. 10m off east shore (running a transducer and PC Sounder approx. 30 cm under water). Starting approximately 200m downstream (north) of the Lockport Dam and ending 100m further north.		
Sept. 23	5550354	647487	5550522	647587	silt/clay/ organic	deciduous: estim: 50% ash, 40% elm,10% oak	1m/10m	Mix: 20% cobble, 40% sand, 40% clay	none	1m/25m	occasional beached	Traveling along east shore	Img_0005.jpg	11:23:22
Sept. 23	5550522	647587	5550849	647498	silt/clay/ organic	deciduous	1m/10m	cobble, gravel	none	1m/25m	occasional beached		Img_0006.jpg & Img_0007.jpg	11:30:22 AM & 11:30:26 AM
East Shoreline Adjacent to Floodway Outlet Mouth														
Sept. 23	5550849	647498	5551210	647400	silt/clay/ organic	deciduous, willow, young poplar, ash	1m/50 m -1m/25m	cobble, gravel; herbaceous & willow/shrub	scrub	1m/50m	occasional beached	Adjacent to Floodway Outlet area	Img_0008.jpg to Img_0021.jpg	11:33:00 AM to 11:36:54 AM
East Shoreline Downstream (North) of Floodway Outlet														
Sept. 23	5551210	647400	5551086	647441	silt/clay/ organic	deciduous	1m/25m	cobble, gravel	scrub & herbaceous	1m/250m	occasional beached	S of Floodway Outlet: mixed deciduous; N of floodway outlet: 20m of mixed deciduous then mowed grasses; steep1m/10m		
Sept. 23	5551086	647441	5551783	647462	silt/clay/ organic	deciduous: 60% ash,10% poplar, 20% willow,10% elm	1m/50m	cobble	herbaceous grasses, sedges	1m/100m	none		Img_0022.jpg to Img_0028.jpg	11:59:40 AM to 12:05:08 PM
Sept. 23	5551783	647462	5553155	648207	silt/clay/ organic	mixed: 80% ash, 20% willow: thick to patchy deciduous w/ occ. open lawn	1m/10m	cobble	herbaceous & grasses	1m/100m	occasional, light beached	At floatplane dock ~2.2km downstream of outlet. Power or hydro stream flow station (?) is @ 5552255N 647728E: residential area starting. This section begins >500m downstream of outlet	Img_0029.jpg to Img_0045.jpg	12:07:18 PM to 12:33:28
West Shoreline Downstream (North) of Floodway Outlet														
Sept. 25	5552334	647637	5552121	647488	silt/clay/ organic	deciduous; mostly ornamental spruce, open grass areas, residential	1m/10m	cobble, gravel	scrub, herbaceous	1m/25/m	none	This section starts at power/flow (?) metre wires(2) crossing river (see above for location). Now traveling along SE shore (i.e. opposite shore from outlet)	Img_0001.jpg & Img_0002.jpg	11:50:58 AM to 11:51:10 AM
Sept. 25	5552121	647488	5551735	647344	silt/clay/ organic	deciduous	1m/10m	cobble, gravel	scrub, herbaceous	1m/20m	none		Img_0003.jpg	11:55:56 AM
Sept. 25	5551735	647344	5551668	647333	silt/clay/ organic	deciduous & open grasses	1m/20m	cobble, gravel	grasses	1m/20m	none	Short area of residential property with less sloping upland	Img_0004.jpg	12:01:08 AM
West Shoreline ~ 500m North of Floodway Outlet to South Extent of Floodway Outlet Mouth														
Sept. 25	5551668	647333	5550759	647460	silt/clay/ organic	deciduous	1m/10m	cobble, gravel	scrub, herbaceous	1m/20m	occasional beached		Img_0005.jpg	12:07:38 AM
West Shoreline Upstream (South) of Floodway Outlet														
Sept. 25	5550759	647460	5550804	647440	silt/clay/ organic	deciduous	1m/30m	cobble, gravel	scrub, herbaceous	1m/20m	none		Img_0006.jpg & Img_0007.jpg	12:14:24 AM & 12:15:42 AM
Sept. 25	5550804	647440	5550624	647488	silt/clay/ organic	deciduous, grasses & gravel road	1m/50m	10% gravel, 90% sand	scrub	1m/20m	none	Commercial structures in this area. By Cats on the Red fishing outfitters ~ 10m out in river by boat launch, wpt#27 @ 5550594N, 647487E	Img_0008.jpg	12:23:18 AM
Sept. 25	5550576	647481	5550173	647297	silt/clay/ organic	deciduous, meadow	1m/10m	cobble, gravel	some scrub, herbaceous	1m/30m	none	Riprap upshore up from bank ~15 to 20m wide for ~100m downstream of end of this section where flooodway concrete walkway/bullkhead starts	Img_0009.jpg	12:26:26 AM

[a] Visual approximation. One meter vertical rise for every X meters horizontal.

[b] Based on grain size scale used by engineers (A.S.T.M. Standards D422-63; D643-78), Dutro et. al, 1989

Photograph 5: Recording bathymetry of the Red River in the vicinity of the Floodway Outlet using a PCSounder® (a GPS-linked bathymetry sounder).

Bottom substrate was sampled on November 4, 2003 within the Red River in the reach 2 km downstream and 1 km upstream of the Floodway Outlet Structure. To minimize disturbance of the bottom substrate, a Ponar grab sampler was used at a limited number of sites (total samples = 28, four samples along each of 7 transects: Table 6D-9 and Figure 6D-2 (Photograph 6). Three sub-samples at each sampling site were taken to confirm uniformity of substrate composition at each site.

TABLE 6D-9

RIVER BED SUBSTRATE SAMPLING DOWNSTREAM AND UPSTREAM OF THE FLOODWAY OUTFALL ON THE RED RIVER, NOV. 4, 2003

Transect #	Sampling Site #	UTM Location		Depth (m)	Substrate Description (Components)[a]		
		Northing	Easting		Primary	Secondary	Tertiary
1 (Downstream)	1	5552336		0.5	Cobble		
	2	5552316	647657	3.5	Cobble		
	3	5552289	647693	3.6	Cobble		
	4	5552255	647734	0.5	Cobble		
2 (Downstream)	1	5551822	647361	0.5	Cobble	Sand	
	2	5551813	647394	3	Gravel	Cobble	Sand
	3	5551801	647434	3	Gravel	Cobble	Sand
	4	5551782	647456	1.2	Cobble	Gravel	Sand
3 (Downstream)	1	5551408	647279	1.2	Cobble	Gravel	Sand
	2	5551409	647319	4.5	Cobble	Gravel	Sand
	3	5551402	647357	3	Gravel	Cobble	Sand
	4	5551404	647387	1	Gravel	Cobble	Sand
4 (Outfall Area)	1	5551134	647328	1	Sand	Gravel	
	2	5551137	647359	2.5	Sand	Cobble	
	3	5551141	647399	3	Sand		
	4	5551127	647432	2	Gravel	Cobble	
5 (Outfall Area)	1	5550957	647363	1	Sand		
	2	5550959	647397	2.2	Sand		
	3	5550947	647435	3.5	Sand		
	4	5550936	647479	2.5	Sand		
6 (Upstream)	1	5550805	647422	0.3	Cobble	Gravel	Sand
	2	5550811	647466	4	Gravel		Some Sand
	3	5550810	647496	4	Cobble	Sand	
	4	5550811	647525	1.5	Gravel	Sand	Cobble
7 (Upstream)	1	5550636	647578	2.5	Cobble		
	2	5550638	647532	3.8	Cobble		Some Sand
	3	5550640	647496	3.3	Cobble	Gravel	Some Sand
	4	5550632	647473	1	Sand		

Note: Three sub-samples were taken at each sampling site using a Ponar dredge to verify substrate characteristics

[a] Based on grain size scale used by engineers (A.S.T.M. Standards D422-63; D643-78), Dutro et. al, 1989

Refer to Figure 6D-2 for locations of substrate sampling transects

Photograph 6: Ponar sampler used to sample bottom substrate in the Red River in the vicinity of the Floodway Outlet

3.1.2 Fish Community Assessment

To confirm existing published information regarding the habitat preferences of fish species present in the Red River, fish were sampled along the Red River east shoreline up to 100m downstream of the Floodway Outlet Structure. This shoreline area will be directly disrupted during construction activities associated with the expansion and modification of the Floodway Outlet Structure. Within the above-described reach of the Red River east shoreline, one large hoop/fyke net, two mini hoop/fyke nets and two folding minnow traps (detailed descriptions in Section 2.1.2.1) were set for 41 to 42 hours from the evening of September 23 to the morning of September 25, 2003: additionally, one large hoop/fyke net, three mini hoop/fyke nets and three folding minnow traps were set in similar locations overnight on September 25, 2003 (Table 6D-10). Locations of net sets were recorded using a Garmin 12L GPS unit.

TABLE 6D-10

FISH SAMPLED ALONG EAST SHORELINE OF RED RIVER WITHIN 100M DOWNSTREAM OF FLOODWAY OUTLET

Capture Method	Gear Set		Gear Checked		Time Gear Set (hrs)	UTM Location		Bottom Substrate	Water Depth (m)	Distance from Shore (m)	Fish Caught		
	Date (2003)	Time	Date	Time		Northing	Easting				Species	Number	Fork Length (cm)
Lg Hoop Net	Sept. 23	16:12	Sept. 25	10:15	42	5551183	647422	Rock/gravel	2.5	4	Walleye	3	38 to 43
											Walleye	1	33
											Sauger	1	38
											Sauger	9	28 to 31
											Sauger	1	23
											White Sucker	1	59
											Sauger	4	27 to 32
Mini Hoop Net	Sept. 23	15:40	Sept. 25	10:05	41.5	5551129	647432	Rock/gravel	2	3	None	-	
Mini Hoop Net	Sept. 23	15:50	Sept. 25	10:05	41.25	5551143	647442	Rock/gravel	2	3	Stonecat	1	-
Minnow Trap	Sept. 23	16:19	Sept. 25	10:45	42.5	5551213	647428	Rock/gravel	1.5	1.5	None	-	
Minnow Trap	Sept. 23	16:25	Sept. 25	10:45	42.5	5551151	647437	Rock/gravel	0.75	1.5	None	-	
*Mini Hoop Net	Sept. 23	16:45	Sept. 25	9:40	41	5550545	647473	Rock/gravel	1	5	None	-	
*Minnow Trap	Sept. 23	16:42	Sept. 25	9:40	41	5550527	647463	Rock/gravel	0.5	3	None	-	
Lg Hoop Net	Sept. 25	10:30	Sept. 26	9:55	23.5	5551183	647422	Rock/gravel	2.5	4	None (net twisted)	-	
Mini Hoop Net	Sept. 25	10:10	Sept. 26	10:15	24	5551129	647432	Rock/gravel	2	3	None	-	
Mini Hoop Net	Sept. 25	10:10	Sept. 26	10:20	24.25	5551143	647442	Rock/gravel	2	3	None	-	
Mini Hoop Net	Sept. 25	11:05	Sept. 26	10:25	23.5	5551218	647417	Rock/gravel	1.75	4	None	-	
Minnow Trap	Sept. 25	10:50	Sept. 26	10:30	23.75	5551213	647428	Rock/gravel	1.5	1.5	None	-	
Minnow Trap	Sept. 25	10:50	Sept. 26	10:35	23.75	5551151	647437	Rock/gravel	0.75	1.5	None	-	
Minnow Trap	Sept. 25	11:05	Sept. 26	10:40	23.5	5551238	647413	Rock/gravel	1.2	4	None	-	

*Note: one mini hoop net and one minnow trap were set on the SW shore just upstream of Cats-on-the-Red as suggested by Stu McKay (owner of Cats-on-the-Red). They were then re-set on Sept. 15th downstream of Outlet.

See Table 6D-11 for Water Chemisty Profile for Sept. 23, 25 and 26, 2003

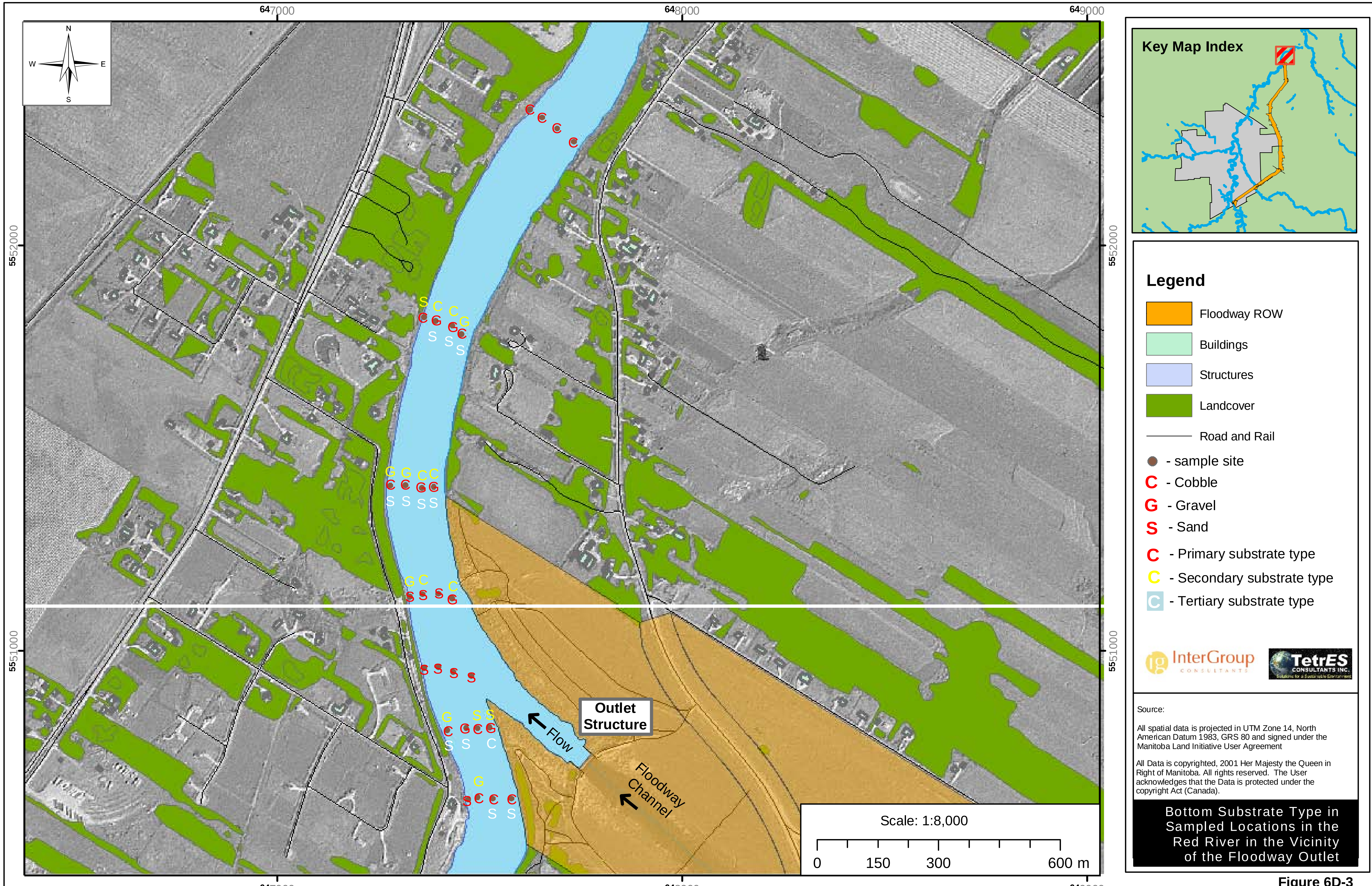
Water chemistry parameters including water temperature, pH and dissolved oxygen were measured when nets were set and pulled (Table 6D-11).

3.2 RESULTS

3.2.1 Aquatic Habitat

Bottom substrate in the Red River in the area adjacent to the Floodway Outlet was primarily hard sand, whereas areas upstream to the Lockport Dam (less than 1 km) and 2 km downstream of the Floodway Outlet consisted of primarily cobble and gravel bottom substrate with some sand (Figure 6D-2. Bathymetry mapping of this same area upstream and downstream of the Floodway Outlet indicates that substantial scouring of the Red River bottom does not occur in the vicinity of the Floodway Outlet copated to the deep souring that occurs as a result of the Lockport Dam operation (Figure 6D-2). However, as indicated in Figure 6D-2, enough scouring occurs near the Floodway Outlet to modify the bottom substrate to primarily hard sand rather than the Cobble/gravel substrate observed upstream and downstream.

Habitat along the east shoreline reach to be disrupted during construction of the expanded Floodway Outlet Structure (approximately 100 metres upstream [north] of the Floodway Outlet) consisted of a cobble/gravel substrate, very similar to the shoreline substrate that occurred in the remaining surveyed two kilometre upstream reach (Tables 6D-8 and 6D-10 Photograph 7). Water chemistry characteristics taken in this location on September 23, 25 and 26, 2003 in conjunction with fish sampling efforts indicated that pH varied between 7.8 and 8.3 Units and dissolved oxygen varied from 9.8 to 10.8 ppm (Table 6D-11).



Source:

All spatial data is projected in UTM Zone 14, North American Datum 1983, GRS 80 and signed under the Manitoba Land Initiative User Agreement

Bottom Substrate Type in Sampled Locations in the Red River in the Vicinity of the Floodway Outlet

Figure 6D-3

TABLE 6D-11

WATER CHEMISTRY IN RED RIVER NEAR FLOODWAY OUTFALL

Date (2003)	Time	UTM Location		Water Chemistry						
				Surface			Mid-Depth [a]		Bottom [b]	
		Northing	Easting	PH (Units)	Dissolved Oxygen (ppm)	Temperature (C°)	Dissolved Oxygen (ppm)	Temperature (C°)	Dissolved Oxygen (ppm)	Temperature (C°)
Sept. 23	17:13	5550911	647432	7.8	9.8	15.4	9.9	15.4	9.9	15.4
Sept. 25	11:30	5551087	647424	8	10.6	13.1	10.7	13	-	-
Sept. 26	10:16	5551052	647422	8.3	10.8	12	10.7	12.3	-	-
Nov. 4 [c]	11:41	5552336	647625	-	14.2	-0.3	-	-	-	-

[a] Mid-depth = 2m on Sept. 23 & 26 and 3 m on Sept. 25

[b] Bottom depth = 4m on Sept. 23 & 26 and 6m on Sept. 25

[c] Bottom substrate sampling done on this date

Photograph 7: Cobble/gravel shoreline substrate along the east Red River shoreline that will be affected by Floodway Outlet Structure modifications and expansion activities.

3.2.2 Fish Community

Results of fish sampling efforts along the east Red River shoreline up to 100m downstream of the Floodway Outlet Structure indicate that a minimum of four fish species were utilizing the near-shore area on September 23 to 25, 2003. A total of 21 fish were caught including sauger, walleye, white sucker and stonecat. The most common fish caught were sauger (71% of catch) and walleye (19%).

3.3 DISCUSSION

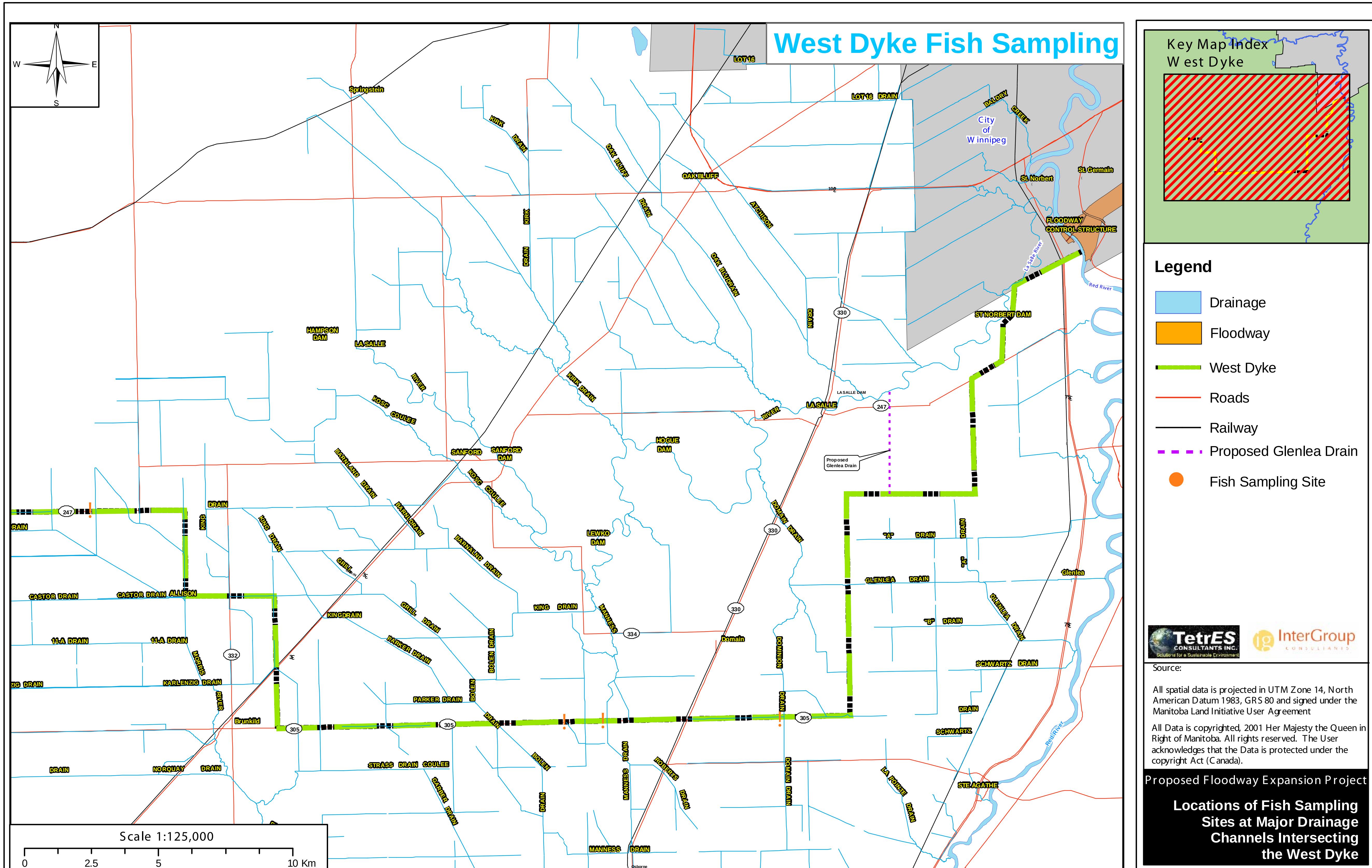
Aquatic habitat in the Red River adjacent to the mouth of the Floodway Outlet appears to be influenced (scoured) by periodic releases of water from the Floodway Channel to the Red River due to the marked differences in bottom substrate in the Red River adjacent to the Floodway Outlet (i.e. hard sand near Outlet compared to primarily cobble/gravel substrate in adjacent upstream and downstream reaches). However, the scouring effect of water released through the Floodway Outlet does not substantially affect water depth, as does the apparent downstream scouring effect of the Lockport Dam.

Aquatic habitat of particular note is the gravel/cobble bottom substrate along the east shoreline reach immediately downstream of the Floodway Outlet that will be disrupted (approximate 100 metre reach) by construction activities associated with the modification and expansion of the Floodway Outlet Structure. This type of substrate near shoreline areas is typically used by spawning walleye, and likely spawning sauger, since the two species spawn in similar habitats; spawning condition male walleye have been sampled in the gravel/cobble substrate north of Lockport (Stewart and Watkinson, 2004). Presence of walleye and sauger along the gravel/cobble east shoreline of the Red River during fish sampling in September 2003 (Section 3.2.2) indicate that those species utilize the gravel/cobble habitat during seasons other than the early spring spawning season. The general reach of the Red River immediately downstream of the Lockport Dam, including the area adjacent to the Floodway Outlet area, is also considered to be one of Manitoba's most valuable recreational fisheries (Stewart and Watkinson, 2004).

4.0 WEST DYKE

4.1 METHODS

On June 6, 2004, fish sampling was conducted using a seine net at four representative drainage channels that intersect the existing and proposed expanded West Dyke Right-of-Way (ROW: Figure 6D-4; Tables 6D-12 and 6D-13, Photograph 8). Locations of fish sampling were recorded using a Garmin 12L GPS unit. Water chemistry parameters including water temperature, pH, conductivity and dissolved oxygen were measured at the time of fish sampling (Table 6D-11). Aquatic habitat characteristics of each sampling site including bottom substrate characterization, drainage channel width and water depth were also recorded.


West Dyke Fish Sampling
Key Map Index
West Dyke
Legend
Drainage
Floodway
West Dyke
Roads
Railway
Proposed Glenlea Drain
Fish Sampling Site
TetrES CONSULTANTS INC.
InterGroup
Source:
All spatial data is projected in UTM Zone 14, North American Datum 1983, GRS 80 and signed under the Manitoba Land Initiative User Agreement
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Proposed Floodway Expansion Project
Locations of Fish Sampling Sites at Major Drainage Channels Intersecting the West Dyke
Scale 1:125,000
0
2.5
5
10 Km
N
S
E
W
City of Winnipeg
Springstein
St. Norbert
St. Germain
FLOODWAY CONTROL STRUCTURE
ST NORBERT DAM
LA SALLE
HAMPSON DAM
SANFORD
SANFORD DAM
HOGUE DAM
LEWKO DAM
CASTOR DRAIN
11-A DRAIN
KARLENZIG DRAIN
ALLISON
Brunkild
NORQUAY DRAIN
STRASS DRAIN COULEE
PARKER DRAIN
KING DRAIN
GLENLEA DRAIN
Glenlea
SCHWARTZ DRAIN
STE AGATHE
Domain
MANNESS DRAIN
Red River
La Salle River
Proposed Glenlea Drain

Figure 6D-4

TABLE 6D-12

FISH SAMPLING RESULTS IN DRAINAGE CHANNELS* INTERSECTING THE WEST DYKE

Capture Method	Time	Date	Total length of net pull (m)	Total width of net pull (m)	UTM Location		Bottom Substrate	Channel Width (m)	Water Depth (m)	Fish Caught		
					Northing	Easting				Species	Number	Comments
Seine Net	11:15	June 6	18	2	5502327	599287	Silt/clay with 10% emergent vegetation (cattails)	2.5 to 3	0.45	Fathead Minnow	2	
										Fathead Minnow	2	Spawning Condition
										Fathead Minnow	2	Young of last year
Seine Net	12:30	June 6	15	2	5494399	612979	Silt/clay	3	0.55	Fathead Minnow	1	Gravid female
										Fathead Minnow	2	Young of last year
Seine Net	12:50	June 6	15	2	5494428	617146	Silt/clay	3.5	0.63	Fathead Minnow	2	
Seine Net	13:12	June 6	16	2	5494677	623754	Flooded grass and cobble	3	0.77 to 1	Crayfish**	2	
										Brown Bullhead**	1	12cm fork length
										Northern Pike	7	Young of year
										Fathead Minnow	1	Young of year
										Fathead Minnow	2	

Notes: Fish were kept (frozen for future examination if necessary) unless otherwise noted

* Four of eight main drainage channels intersecting the West Dyke right-of-way

** Released

Snails were also abundant in drainage channels adjacent to the West Dyke

See Table 6D-13 for Water Chemisty Profile for June 6, 2004

TABLE 6D-13

WATER CHARACTERISTICS IN WEST DYKE CHANNELS* AT FISH SAMPLING SITES

Date (2004)	Time	Location			Max. Depth (m)	Water Chemistry at Surface			
		General Description	UTM Northing	UTM Easting		Temp. (°C)	Dissolved Oxygen (ppm)	PH (Units)	Cond. (µs)
June 6	11:15	Drainage Ditch intersecting proposed expanded West Dyke at PTH 247 (6.5 km W. of Allison Drain)	5502327	599287	0.45	19.5	1.3 (at 8 cm depth)	7.5	220
June 6	12:30	Drainage Ditch intersecting West Dyke at PTH 305 (4 km E. of Manness Drain)	5494399	612979	0.55	19.3	4.4 (at 8 cm depth)	7.7	370
June 6	12:50	Manness Drain at PTH 305 where it intersects with West Dyke	5494428	617146	0.63	18.7	5.2 (at 8 cm depth)	7.7	460
June 6	13:12	Four culvert drainage ditch intersecting with West Dyke at PTH 305 7 kms W. of Manness Drain	5494677	623754	0.77 to 1	19.4	4.1 (at 8 cm depth)	7.7	150

* Four of eight main drainage channels intersecting the West Dyke right-of-way

Photograph 8: Example of one of the main drainage ditches intersecting the West Dyke that were sampled for fish, June 2004

4.2 RESULTS

Reconnaissance survey along the length of the existing and proposed expanded West Dyke ROW on June 6, 2004 indicated that drainage ditches occur along either side of the West Dyke ROW (EIS Terrestrial Section 7). The width of drainage ditches paralleling the West Dyke ROW ranged from 20 to 0.5 metres wide and varied with location and extent of recent rainfall. Water chemistry measurements taken on June 6, 2004 in conjunction with fish sampling efforts at four drainage channels that intersect the West Dyke ROW indicted that pH ranged from 7.5 to 7.7 units, conductivity ranged from 220 to 460 µs, water temperature ranged from 18.7 to 19.5 and dissolved oxygen levels varied from 1.3 to 5.2 ppm (Table 6D-13). Bottom substrate was typically clay with varying extents of flooded grasses, willows and aquatic plants such as cattails and sedges. Results of more detailed vegetation surveys/reconnaissance being conducted during spring, summer and fall, 2004 will be provided in a supplementary report.

Results of fish sampling efforts at four of the eight land drainage ditches that intersect the existing and proposed expanded West Dyke ROW on June 6, 2004 indicated that fathead minnows were common in all four of the drainage ditches, with young of the year Northern pike and one brown bullhead caught in a culverted drainage channel seven kilometres west of the Manness Drain (Table 6D-13 and Figure 6D-5).

4.3 DISCUSSION

Aquatic habitat, in particular fish habitat within the drainage ditches and channels adjacent to the West Dyke ROW, is intermittent/ephemeral since much of the shallow ditch and drainage channels typically dry up or are reduced to occasional small ponds during late summer/fall (EIS Section 6.4.2.3). The diversity of fish using ditch and drainage channel habitat adjacent to the West Dyke ROW would be considered low, and limited to those species that tolerate shallow stagnant waters that are subject to high water temperatures and low dissolved oxygen (e.g. the fathead minnow). The ability of the fathead minnow to tolerate very low oxygen levels was demonstrated during fish sampling efforts on June 6, 2004 when this species (several of which were in spawning condition) was caught in a drainage channel where the dissolved oxygen level was 1.3 ppm, which is well below the dissolved oxygen level (approximately 5 ppm [mg/L] Manitoba Conservation 2002) required to sustain most other fish species (Table 6D-12).

Certain drainage ditches that intersect the West Dyke ROW receive flow from the La Salle River (a tributary of the Red River) during spring high water levels. The La Salle River is the likely source for the Northern pike and brown bullhead caught in the drainage channel seven kilometres west of the Manness Drain. The presence of young of the year Northern pike indicate that this drainage channel was likely used by spawning Northern pike that would have entered the drainage channel from the La Salle River. This drainage channel, and possibly other main drainage channels intersecting the La Salle River, likely provides spring spawning habitat for other fish species that spawn in small tributary streams of rivers.

5.0 REFERENCES

Dutro, J.T. Jr., R.V. Dietrich and R.M. Foose. 1989. AGI Data Sheets for Geology in the Field, Laboratory and Office. American Geological Institute, Alexandria, VA

Manitoba Conservation, Water Branch 2002. Manitoba Water Quality Standards, Objectives, and Guidelines (Final Draft). Manitoba Conservation Report 2002-11

Stewart, K.W. and D.A. Watkinson. 2004. The Freshwater Fishes of Manitoba. University of Manitoba Press, Winnipeg, Manitoba

Zrum, L. and S. Davies. 2000. Phase Two Technical Memorandum for Red and Assiniboine Ammonia Criteria Study: Fish Population Technical Memorandum #FP-03: Abundance, Composition and Distribution of Benthic Invertebrates in the Red and Assiniboine Rivers within the City of Winnipeg, 1999. Submitted by North/South Consultants to City of Winnipeg Project Management Committee.

APPENDIX 6E

Aquatic Habitat Utilization: Literature Study

1.0 INTRODUCTION

The Regional Study Area for the Red River Floodway Expansion Project, encompasses the Red River Valley extending from the Canada-Untied States border in the south northward to (and including) Lake Winnipeg and for the eastern boundary of the Red River drainage basin westward to the Portage Diversion.

The study area is comprised of relatively small portions of the Red and Assiniboine River Basins. The Red and Assiniboine Rivers drain the prairie regions of southern Manitoba, southeastern Saskatchewan, North Dakota, northern South Dakota and northwestern Minnesota. Both Basins are underlain by limestone bedrock covered with a thick deposit of clay. Soils in the region are black and fine textured. The Red River Valley plain is virtually level while the Assiniboine River passes through the Manitoba escarpment in the western portion of the province (Tet*rES* 2002).

The Red River Basin occupies a land area of approximately 127,000 km^2, 20% of which is located in Manitoba (26,000 km^2). The remaining 80% of the Red River Basin is located in North Dakota, South Dakota and Minnesota. The basin, almost as wide as it is long, is commonly referred to as the Red River Valley. This broad, flat plain flanking both sides of the Red River is actually a lake plain which was formerly the bed of old glacial Lake Agassiz.

Historical surveys in the Red River have identified 66 species of fish (57 native and 9 introduced), of which 18 species are commonly caught by anglers and researchers (Appendix 6D, Table 1). Fish species in the Assiniboine River are similar to those in the Red River. Thirty-two species of clams (23 common), and 15 species of snails (8 common) have been identified in the Red River Basin (Appendix 6D, Table 2) Representatives of over 50 families of invertebrates have also been caught throughout the Red River Basin.

Three fish species known to exist in the Red River Basin are species of special concern listed under the *Species at Risk Act* (SARA): Bigmouth Buffalo, Chestnut Lamprey, and Silver Shub. No Manitoba fish are listed as endangered, and the two threatened species (Carmiine Shiner and Shortjaw Cisco) are not present in the Red River. The Lake Winnipeg Physa Snail is currently being considered for listing under the Species at Risk Act. It is known to exist in Lake Winnipeg, but has never been identified in any adjacent tributaries of Lake Winnipeg, including the Red River. The Lake Winnipeg Physa snail is currently the only Manitoba Mollusc mentioned in the SARA listings.

General ecology for fish species occurring in the study area has been reported in the literature and is shown in (Appendix 6B, Table 1). A review of previous aquatic studies in the Red and Assiniboine Rivers in the vicinity of Winnipeg was conducted in an attempt to estimate populations and identify local habitat preferences for the fish and invertebrate species. However, historical surveys have produced such variable results that no conclusions can be drawn to estimate populations or habitat preference in the Red River.

Studies that are of particular relevance to the Floodway Expansion Project are recent studies conducted by North/South Consultants Inc. from October 1998 to November 1999 (Cooley and Davies 2000, Remnant *et al.* 2000, Zrum and Davies 2000, North/South 1999a, Lawrence and Barth 2000, Barth and Lawrence 2000, Eddy *et al.* 2000, North/South 2000, Davies and Zrum 2000, Davies Toews 2000, Toews and Davies 2000). These studies gathered information on water chemistry, physical characteristics of the rivers, and the benthic invertebrate community in order to characterize fish habitat in the Red and Assiniboine Rivers in and near the vicinity of the City of Winnipeg. The surveys also produced information on general fish health and movements within the study area. These data have been re-examined by Tetr*ES* Consultants Inc. in order to assess the need and practicality of conducting similar surveys using the same methodologies to strengthen the existing baseline database for the Red and Assiniboine Rivers.

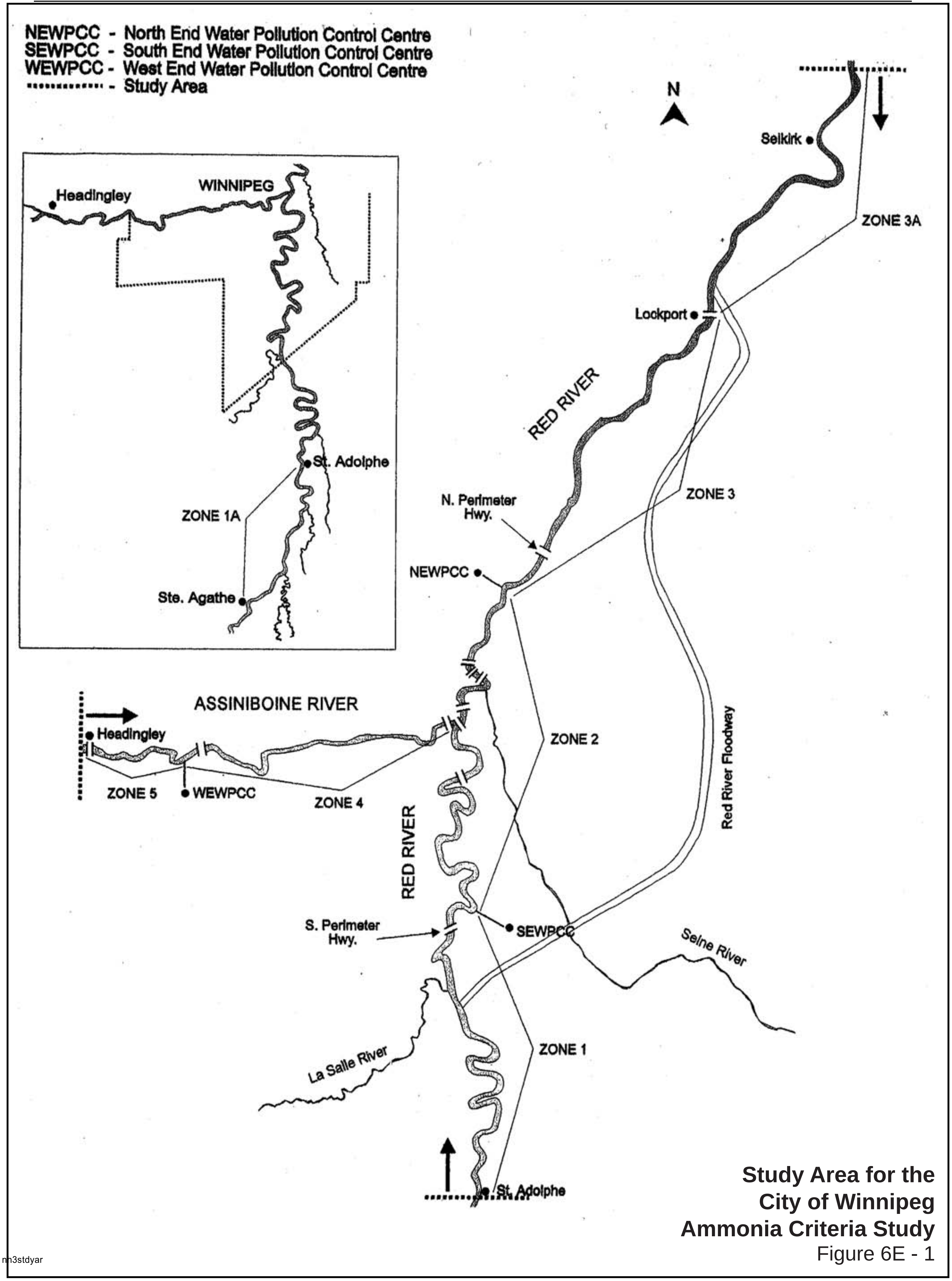
In particular, fish population data, benthic invertebrate data, and data concerning the frequencies of deformities, erosions, lesions, and tumours (DELTs) were re-examined and compared to physical characteristics of the river in order to identify trends, if any existed, in fish catch, fish health, and benthic community composition in given locations.

To facilitate a sampling regime, the North/South studies had identified seven zones within the study area (Figure 6E-1). These zones were based on river confluences and locations of the City of Winnipeg water pollution control centres. The river zones were further sectioned into segments of straightaways and river bends (Figure 6E-2). The Red River contained 86 segments in the study area from segment one at the upstream extremity near St. Adolphe, MB to segment 86 downstream near Selkirk, MB. The Assiniboine River consisted of 30 segments from 101 upstream near Headingly, MB to 130 downstream at its confluence with the Red River.

2.0 BOTTOM SUBSTRATE DATA

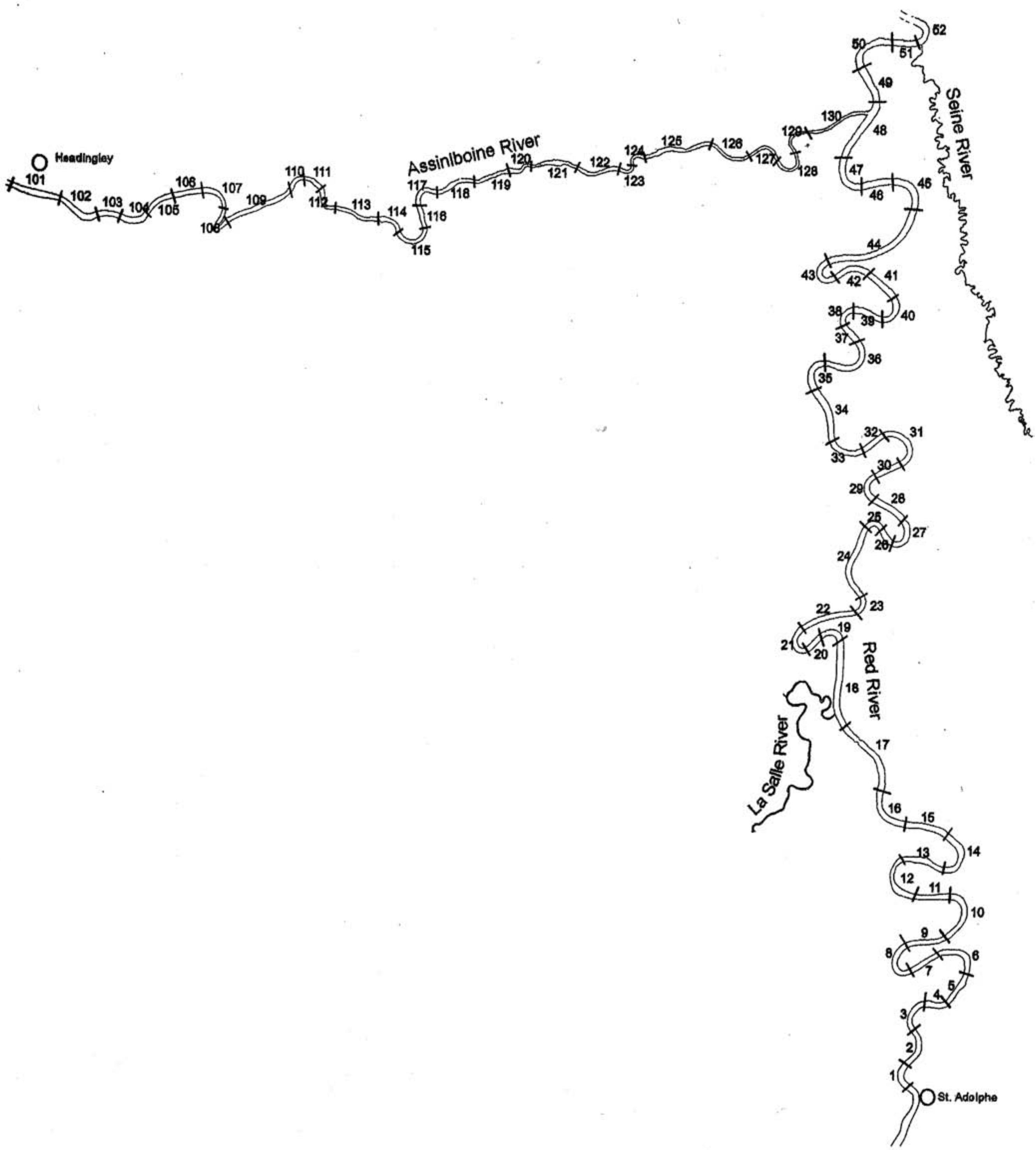
Substrate data from the North/ South study (North/South 2000) was characterized using several different descriptive techniques, and was the basis for a map of the substrate composition of the rivers (Figures 6E-4 to 6E-9). Substrate was described for each segment as a percentage of hard, medium and soft substrates in that segment. Fish capture and benthic invertebrate raw data tables used a single point substrate type was listed for many net set or grab location descriptions. Substrate type at point of set was noted with many net sets but it was not recorded for other methods by which fish were captured such as seine netting and electrofishing sites. A third more complete substrate analysis detailing the physical characteristics of the river bottom was also available. This comprehensive substrate table was the most reliable source of substrate data.

Methods used in the detailed physical characterization of the river bottoms included sampling four transects within each segment. Along each transect, a substrate sample was taken with a Ponar at three points: left stream, right stream, and mid-channel. The Global Positioning System (GPS) based UTM coordinates of each sample point were recorded. Each sample was analysed and particle size and compaction were recorded. Using these data, each sample was classified as hard, medium or soft.



Study Area for the City of Winnipeg Ammonia Criteria Study

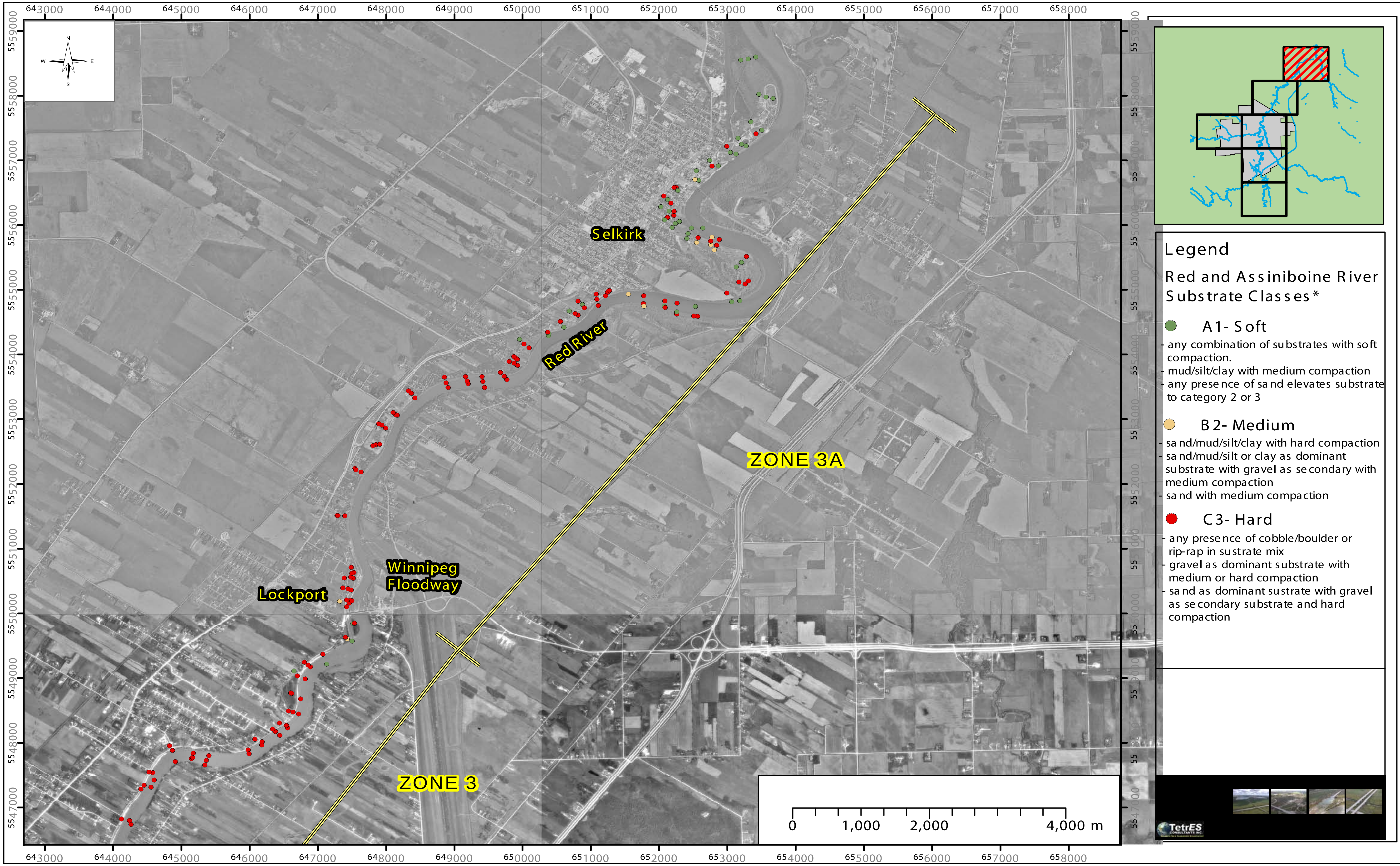
Figure 6E - 1

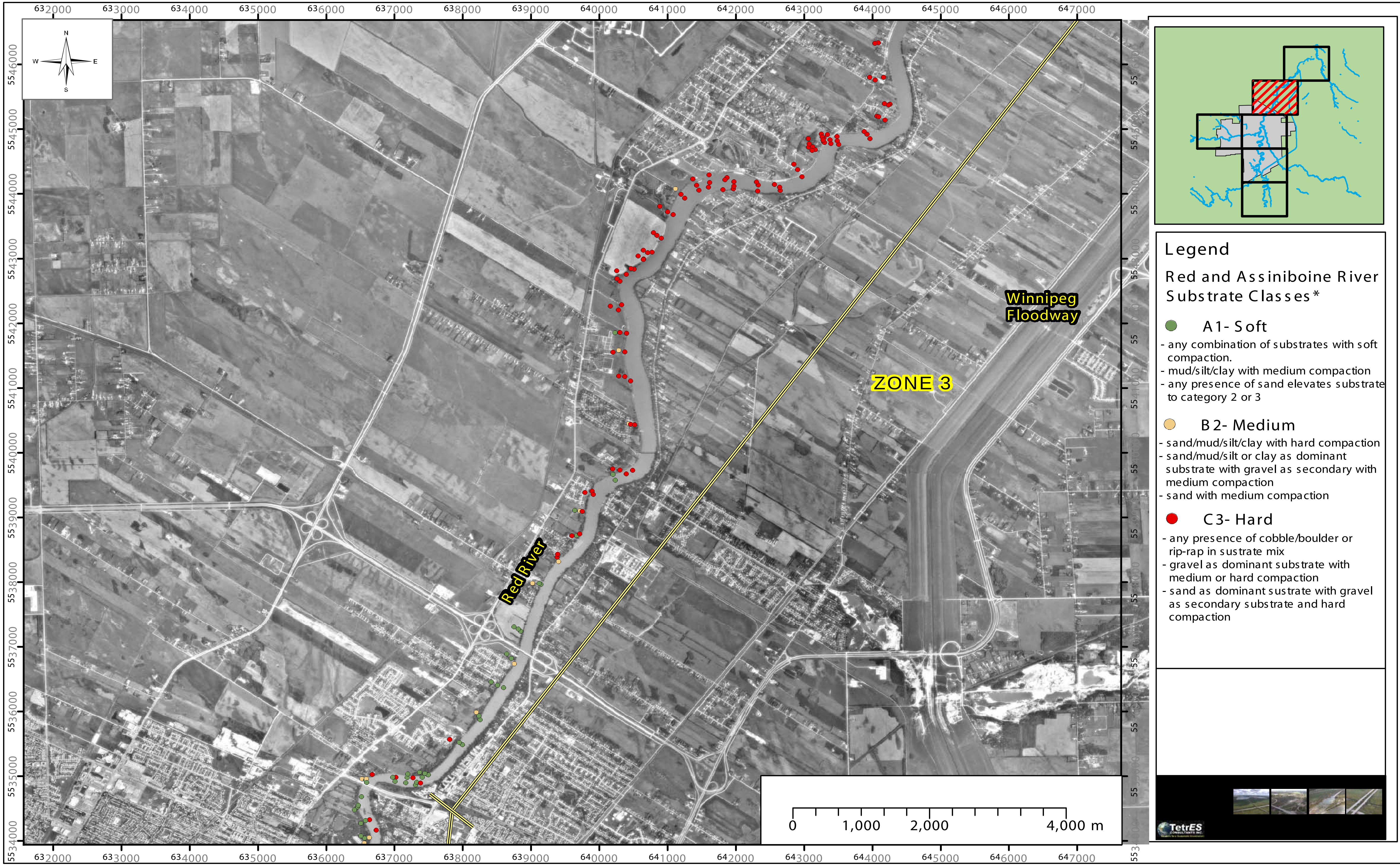


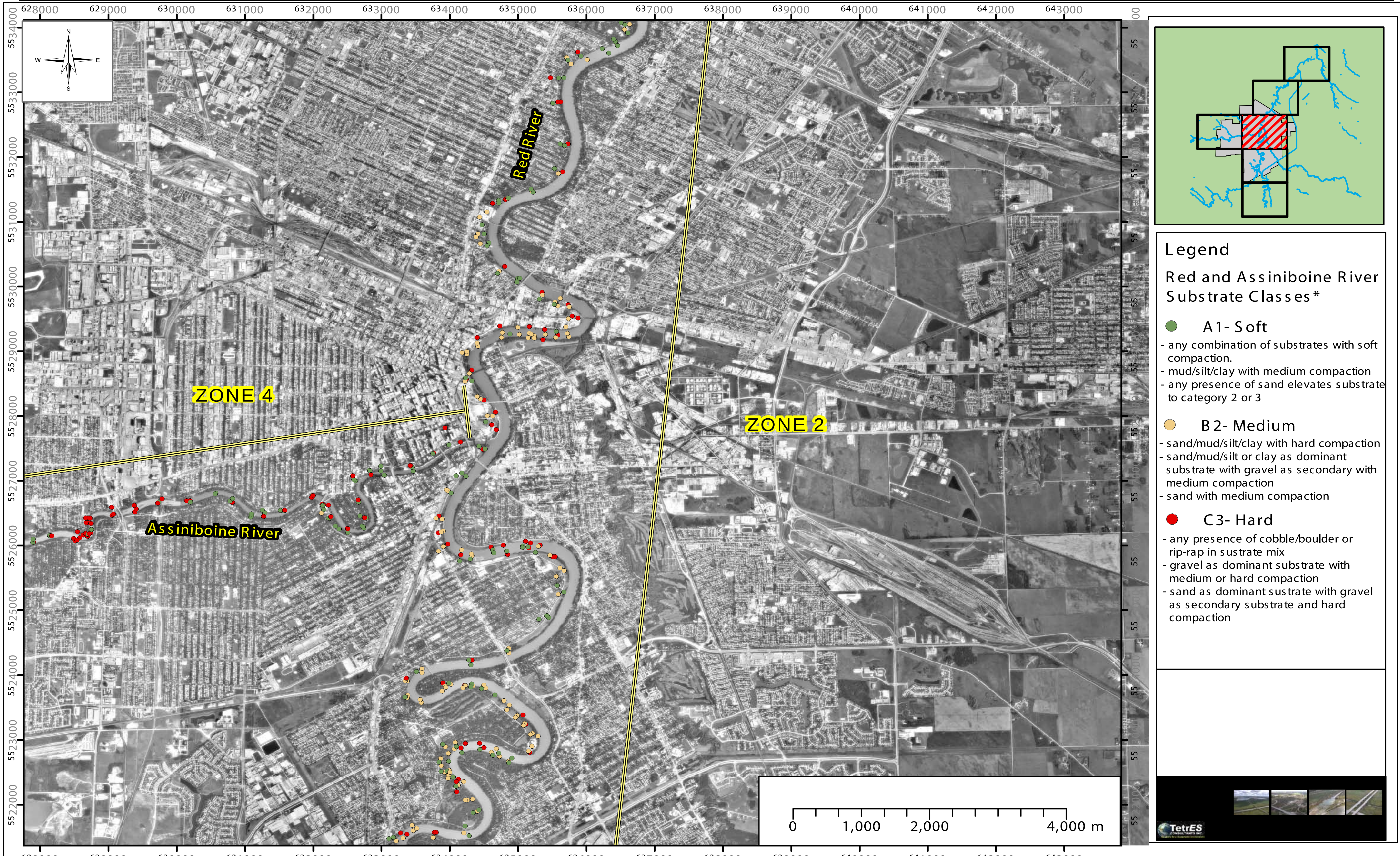
Study Segments for the City of Winnipeg Ammonia Criteria Study

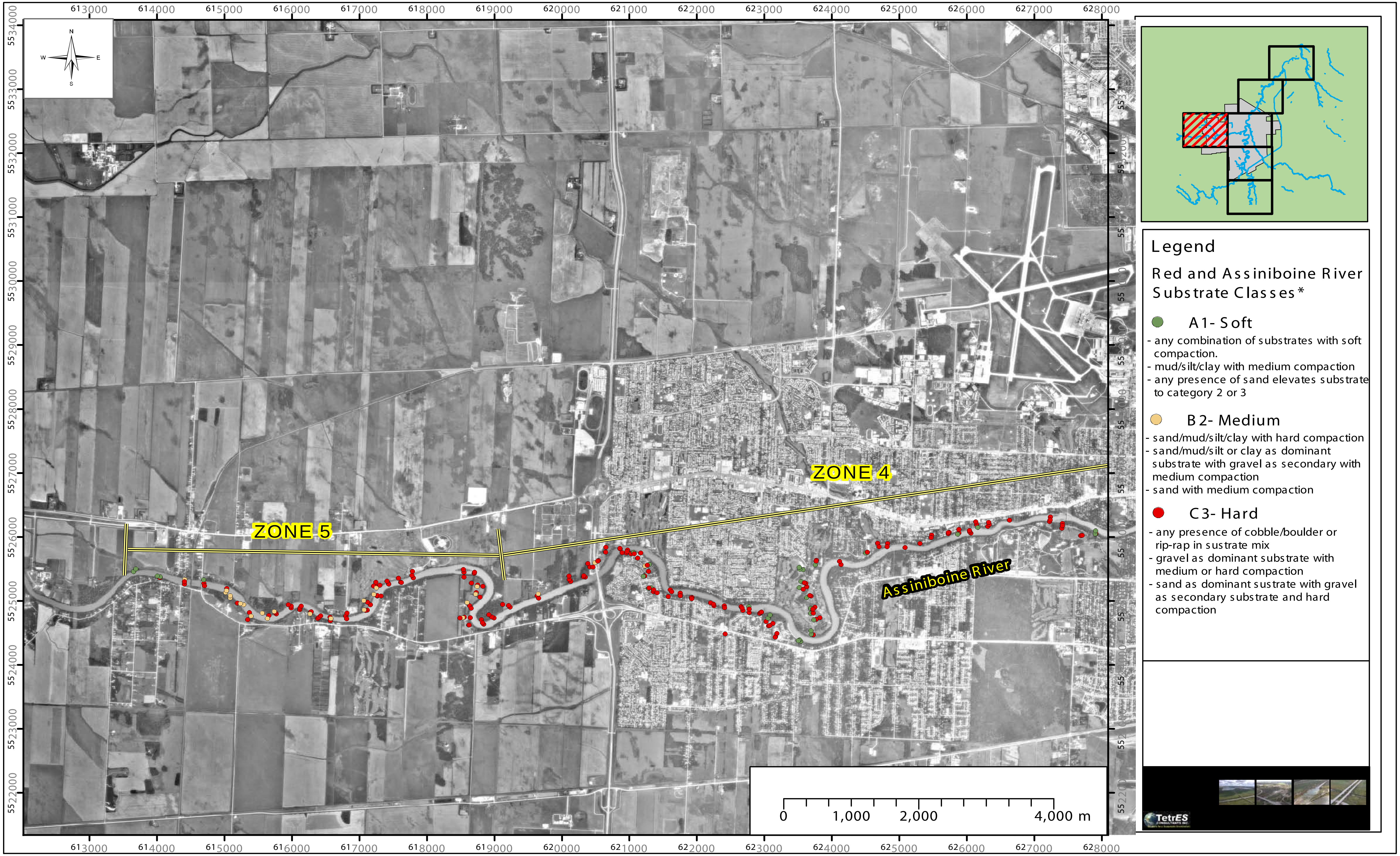
Figure 6E - 2

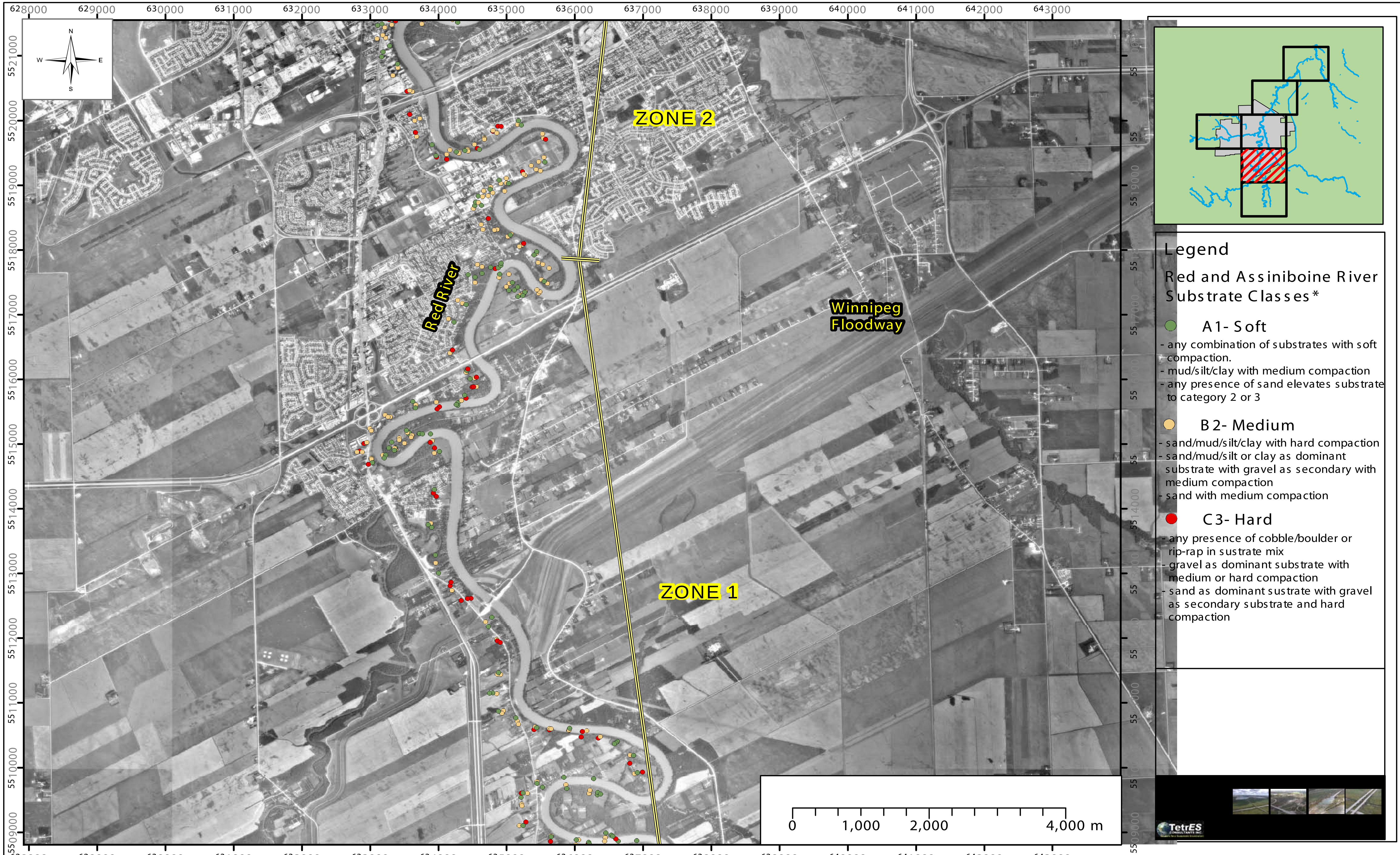
serments

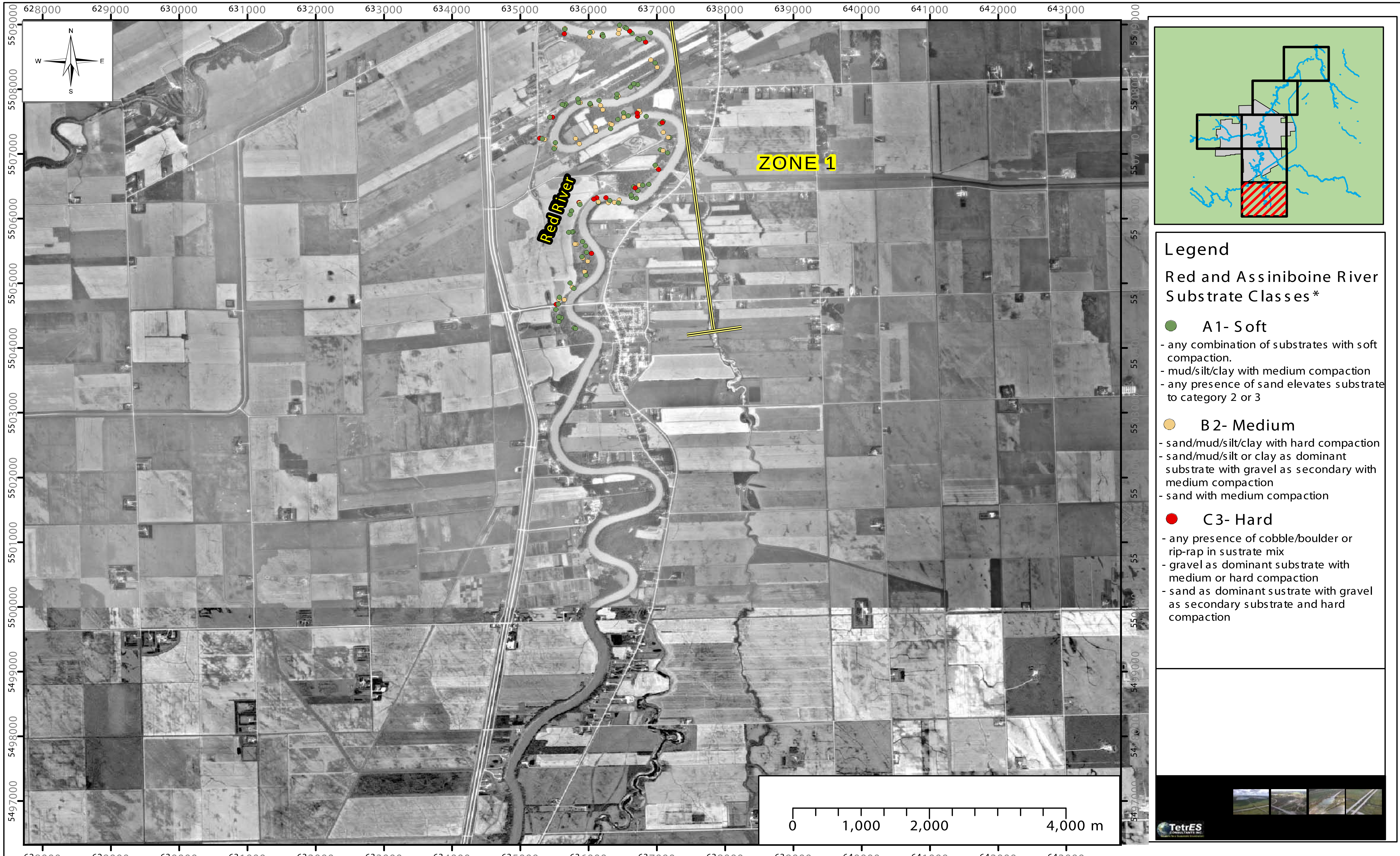

Selkirk
Red River
ZONE 3A
Winnipeg Floodway
Lockport
ZONE 3
0
1,000
2,000
4,000 m
Legend
Red and Assiniboine River Substrate Classes*
A1- Soft
- any combination of substrates with soft compaction.
- mud/silt/clay with medium compaction
- any presence of sand elevates substrate to category 2 or 3
B2- Medium
- sand/mud/silt/clay with hard compaction
- sand/mud/silt or clay as dominant substrate with gravel as secondary with medium compaction
- sand with medium compaction
C3- Hard
- any presence of cobble/boulder or rip-rap in sustrate mix
- gravel as dominant substrate with medium or hard compaction
- sand as dominant sustrate with gravel as secondary substrate and hard compaction
TetrES


Red River
Winnipeg Floodway
ZONE 3
0
1,000
2,000
4,000 m
Legend
Red and Assiniboine River Substrate Classes*
A1- Soft
- any combination of substrates with soft compaction.
- mud/silt/clay with medium compaction
- any presence of sand elevates substrate to category 2 or 3
B2- Medium
- sand/mud/silt/clay with hard compaction
- sand/mud/silt or clay as dominant substrate with gravel as secondary with medium compaction
- sand with medium compaction
C3- Hard
- any presence of cobble/boulder or rip-rap in sustrate mix
- gravel as dominant substrate with medium or hard compaction
- sand as dominant sustrate with gravel as secondary substrate and hard compaction
TetrES


Red River
Assiniboine River
ZONE 4
ZONE 2
N
S
E
W
0
1,000
2,000
4,000 m
Legend
Red and Assiniboine River Substrate Classes*
A1- Soft
- any combination of substrates with soft compaction.
- mud/silt/clay with medium compaction
- any presence of sand elevates substrate to category 2 or 3
B2- Medium
- sand/mud/silt/clay with hard compaction
- sand/mud/silt or clay as dominant substrate with gravel as secondary with medium compaction
- sand with medium compaction
C3- Hard
- any presence of cobble/boulder or rip-rap in sustrate mix
- gravel as dominant substrate with medium or hard compaction
- sand as dominant sustrate with gravel as secondary substrate and hard compaction
TetrES


ZONE 4
ZONE 5
Assiniboine River
0 1,000 2,000 4,000 m
Legend
Red and Assiniboine River Substrate Classes*
A1- Soft
- any combination of substrates with soft compaction.
- mud/silt/clay with medium compaction
- any presence of sand elevates substrate to category 2 or 3
B2- Medium
- sand/mud/silt/clay with hard compaction
- sand/mud/silt or clay as dominant substrate with gravel as secondary with medium compaction
- sand with medium compaction
C3- Hard
- any presence of cobble/boulder or rip-rap in sustrate mix
- gravel as dominant substrate with medium or hard compaction
- sand as dominant sustrate with gravel as secondary substrate and hard compaction


ZONE 2
ZONE 1
Red River
Winnipeg Floodway
N
S
E
W
Legend
Red and Assiniboine River Substrate Classes*
A1- Soft
- any combination of substrates with soft compaction.
- mud/silt/clay with medium compaction
- any presence of sand elevates substrate to category 2 or 3
B2- Medium
- sand/mud/silt/clay with hard compaction
- sand/mud/silt or clay as dominant substrate with gravel as secondary with medium compaction
- sand with medium compaction
C3- Hard
- any presence of cobble/boulder or rip-rap in sustrate mix
- gravel as dominant substrate with medium or hard compaction
- sand as dominant sustrate with gravel as secondary substrate and hard compaction
0
1,000
2,000
4,000 m
TetrES


N
S
E
W
Red River
ZONE 1
628000
629000
630000
631000
632000
633000
634000
635000
636000
637000
638000
639000
640000
641000
642000
643000
5509000
5508000
5507000
5506000
5505000
5504000
5503000
5502000
5501000
5500000
5499000
5498000
5497000
0
1,000
2,000
4,000 m
Legend
Red and Assiniboine River Substrate Classes*
A1- Soft
- any combination of substrates with soft compaction.
- mud/silt/clay with medium compaction
- any presence of sand elevates substrate to category 2 or 3
B2- Medium
- sand/mud/silt/clay with hard compaction
- sand/mud/silt or clay as dominant substrate with gravel as secondary with medium compaction
- sand with medium compaction
C3- Hard
- any presence of cobble/boulder or rip-rap in sustrate mix
- gravel as dominant substrate with medium or hard compaction
- sand as dominant sustrate with gravel as secondary substrate and hard compaction
TetrES

TetrES Consultants Inc. used these classifications (12 points per segment) and their associated UTM coordinates to developed a substrate map of the river bottom (Figures 6E-3 to 6E-8).

3.0 FISH CAPTURE DATA

3.1 HOOPNET DATA

The North/South hoopnet data (North/South 1999b) were reorganized in order to provide comparisons between rivers, and among zones and segments. Examined were:

- Catch per Unit Effort (CPUE) was calculated for the whole study area (Table 6E-1), and for each specific zone (Table 6E-2) for each month that hoopnetting was conducted.
- Catch numbers (Table 6E-3) and species composition (Table 6E-4) of the study area and for each specific zone (Tables 6E-5 and 6E-6).
- Average monthly CPUE for each species in each zone for which standard deviation was calculated (Table 6E-7).

TABLE 6E-1

CPUE FISH CAUGHT BY HOOPNET SETS IN RED AND ASSINIBOINE RIVERS, 1999

Month	Total fish caught	Avg. Catch per 24 hour period	Number of nets set
July	109	7.354	14
August	789	31.617	27
September	326	18.533	18
Total	1224	NA	59

Note: All hoop nets were set downstream of Floodway Inlet

* CPUE = Catch per unit effort

Data source: North/South 1999b

Table 6E-2

CPUE FOR 24 HR PERIOD BY MONTH BY ZONE FOR HOOPNETS**

Zone	Month	Avg. CPUE/ 24 hr period	Standard Duration of CPUE
1	July	2.0	0.5
1	August	NA	
1	September	10.8	8.5
2	July	8.0	8
2	August	12.6	6.1
2	September	33.1	21.9
3	July	10.1	6.2
3	August	43.8	49.3
3	September	16.4	16.9
4	July	8.4	16
4	August	10.9*	3.2
4	September	13.6*	5.1
5	July	4.7	1.4
5	August	NA	
5	September	3.6	6.2

CPUE= Catch per unit effort

* SD and Avg CPUE calculated using only two samples and the mean of the two samples to make a 'hypothetical' third sample such that SD could be calculated.

** Average CPUE (Catch per unit effort) calculated by averaging the CPUE for each net set.

Data source: North/South 1999b

TABLE 6E-3

TOTAL HOOPNET CATCH BY SPECIES

Fish Species	July	August	September
Carp	12	13	1
Channel Catfish	26	329	170
Freshwater Drum	22	64	11
Golden Redhorse	1	6	1
Mooneye	1	0	0
Northern Pike	0	7	0
Quillback	11	90	10
Rock Bass	1	0	0
Sauger	3	177	33
Shorthead Redhorse	15	43	25
Silver Redhorse	3	2	0
Walleye	1	14	0
White Sucker	13	40	65
Bigmouth Buffalo	0	1	0
Black Crappie	0	1	0
Goldeye	0	2	2
Brown Bullhead	0	0	4
Burbot	0	0	4
Total	109	789	326

Note: All hoop nets were set downstream of the Floodway Inlet.

Data source: North/South 1999b

TABLE 6E-4

SPECIES COMPOSITION OF EACH MONTH'S HOOPNET CATCH

Fish Species	July	August	September
Carp	11%	2%	0%
Channel Catfish	24%	42%	52%
Freshwater Drum	20%	8%	3%
Golden Redhorse	1%	1%	0%
Mooneye	1%	0%	0%
Northern Pike	0%	1%	0%
Quillback	10%	11%	3%
Rock Bass	1%	0%	0%
Sauger	3%	22%	10%
Shorthead Redhorse	14%	5%	8%
Silver Redhorse	3%	0%	0%
Walleye	1%	2%	0%
White Sucker	12%	5%	20%
Bigmouth Buffalo	0%	0%	0%
Black Crappie	0%	0%	0%
Goldeye	0%	0%	1%
Brown Bullhead	0%	0%	1%
Burbot	0%	0%	1%
	100%	100%	100%

Note: All hoop nets were set downstream of Floodway Inlet

Data source: North/South 1999b

Reorganization of the North/South data (Tetr*ES* 2002) was necessary to determine how fish species composition of the Red and Assiniboine Rivers changes by season and location. These were then compared with the habitat map to identify temporal and habitat-dependant trends.

A total of 1224 fish representing 18 species were caught within the study area in 59 24-hour hoopnet sets during July, August and September of 1999 (Tetr*ES* 2002). Catch per Unit effort was highest in August when an average of 31.6 fish were caught per 24-hour period. Species diversity of catch also peaked in August. The dominant species in hoopnet catches was channel catfish, followed by white sucker and sauger.

Average CPUE for each species was further examined by separating average CPUE for each species by month and by zone (Table 6E-7). Comparison of average CPUE can provide an indication of each species abundance throughout the study area by season provided that sampling methods are consistent. Catch data from zones 1 and 4 cannot be used to draw reliable conclusions since hoopnetting did not occur during all three months. In examination of hoopnetting data for Zones 2,3, and 4, some apparent trends are visible (Table 6E-7), however small sample size and large standard deviations suggest these trends should be treated with caution.

Some species were hoopnetted in August that were not hoopnetted in any other month. Those caught only in August were: northern pike, bigmouth buffalo, and black crappie. Brown bullhead, burbot and white sucker in the Red River appear to increase in activity in September, the first two species being hoopnetted only in that month. Silver redhorse seem to peak in activity in the Assiniboine River in July and decline throughout the summer. The same occurs with carp in the Red River. Fish whose activity seems to peak in August in the Red River are freshwater drum, quillback, northern pike, walleye and sauger. Both channel catfish and shorthead redhorse seem to be most active in the upstream reaches in September.

TABLE 6E-7
TRENDS IN HOOPNET NET CATCH IN RED AND ASSINIBOINE RIVERS, 1999

Species	Month of Peak Catch*	Location of Peak Catch	Spawning Period **
Bigmouth Buffalo Black Crappie	NA (Limited catch) NA (Limited Catch)		mid-May May-mid July
Brown Bullhead	September	Red River	May-June
Burbot	September	Red River	November-May
Carp	July	Red River	Spring-Early Summer
Channel Catfish	August September	Downstream Upstream	Late spring- summer
Freshwater Drum	August	Red River	July
Golden Redhorse	August	Assiniboine	Late May
Goldeye	NA (Limited Catch)		May- Early July
Mooneye	NA (Limited Catch)		April- May
Northern Pike	August	Red River	April-May
Quillback	August	Red River	April- May
Rockbass Sauger	September August	Assiniboine Red River	June May-June
Shorthead Redhorse	August September	Downstream Upstream	Late April
Silver Redhorse	July	Assiniboine	Spring
Walleye	August	Red River	April
White Sucker	September	Red River	May to June

* based on observable trends in hoopnet data ** (Scott and Crossman 1985) Data source: North/South 1999b

In some cases, only two hoopnets were set in a given zone in a month, so the average of the two netsets was included as a hypothetical data point in order to calculate a standard deviation. As indicated in Table 6E-8, large variation in the CPUE data is evident.

4.0 GILLNET DATA

North/South gillnetting data (Tetr*ES* 2002) were also re-examined in the following manner:

- Catch per Unit Effort (CPUE) for the study area (Table 6E-9), and for each zone (Table 6E-10) during each month that gillnetting was conducted.
- Total catch numbers (Table 6E-11) and species composition (Table 6E-12) of the study area and for each zone (Table 6E-13) and (Table 6E-14).
- The species and numbers caught in each mesh size of a standard gang gillnet set in each zone (Table 6E-15).
- CPUE for each mesh size in Zone 3A only since this was the only zone where sufficient information regarding mesh size used was provided (Table 6E-16).

TABLE 6E-9

CPUE* FOR GILLNET SETS IN RED AND ASSINIBOINE RIVERS 1999

Month	Number of nets set	Total # of fish caught	Average catch per 24 hour	SD
February**	12	14	1.2927	1.67
March	27	114	4.65322	7.65
July	20	59	11.13847	10.26
September	11	19	8.255437	9.85

Notes: All nets were set downstream of control structure. Nets set Feb 28 and checked Mar 1st are enumerated under March's totals

* CPUE: Catch per unit effort

Data source: North/South 1999b

TABLE 6E-10

CPUE FOR 24 HOUR PERIOD BY MONTH BY ZONE FOR GILLNET

Time/Location of Net Sets	***Average CPUE/24 hr period*****	***SD of CPUE***
Zone 1		
Winter	2.7	3.3
July	1.4	2.4
Sept	NA	NA
Zone 2		
Winter	1.9	1.7
July	12.6	14.4
Sept	11.8	9.8
Zone 3		
Winter	0.0	NA
August	16.6	6.3
Sept	NA	NA
Zone 3A		
Winter	14.1	10.6
August	NA	NA
Sept	NA	NA
Zone 4		
Winter	0.0	NA
August	8.9	11.2
Sept	6.8	11.7
Zone 5		
Winter	0.4	0.7
August	8.2*	0.6
Sept	0*	0

* SD and Avg CPUE calculated using only two samples and mean.
** Average CPUE calculated by averaging the CPUE for each net set.
CPUE: Catch per unit effort
SD: Standard Duration

Notes: All nets were set downstream of control structure. Nets set Feb 28 and checked Mar 1st are enumerated under March's totals

Data source: North/South 1999b
.3

TABLE 6E-11

GILLNET CATCH BY SPECIES

Fish Species	*Feb***	*Mar*	*July*	*Sept*
White Sucker	1	28	5	
Goldeye	7	15	13	2
Sauger	2	19	3	4
Stonecat			2	3
Northern Pike		8	8	
Walleye		7	1	
Mooneye	3	2	3	
Carp		5	2	2
Channel Catfish	1	2	11	5
Freshwater Drum		5	1	
Shorthead Redhorse		2	6	2
Black Bullhead			3	
Brown Bullhead			1	
Burbot		1		1
Silver Chub		1		
Lake Cisco		19		
Total	14	114	59	19

Notes: All nets were set downstream of Inlet Control Structure. **Nets set Feb 28 and checked Mar 1st are enumerated under March's totals

Data source: North/South 1999b

TABLE 6E-12

SPECIES COMPOSITION OF GILLNET CATCH BY MONTH

Fish Species	*Feb***	*Mar*	*July*	*Sept*
White Sucker	7%	25%	8%	0%
Goldeye	50%	13%	22%	11%
Sauger	14%	17%	5%	21%
Stonecat	0%	0%	3%	16%
Northern Pike	0%	7%	14%	0%
Walleye	0%	6%	2%	0%
Mooneye	21%	2%	5%	0%
Carp	0%	4%	3%	11%
Channel Catfish	7%	2%	19%	26%
Freshwater Drum	0%	4%	2%	0%
Shorthead Redhorse	0%	2%	10%	11%
Black Bullhead	0%	0%	5%	0%
Brown Bullhead	0%	0%	2%	0%
Burbot	0%	1%	0%	5%
Silver Chub	0%	1%	0%	0%
Lake Cisco	0%	17%	0%	0%
Total	100%	100%	100%	100%

Notes: All nets were set downstream of control structure. **Nets set Feb 28 and checked Mar 1st are enumerated under March's totals

Data source: North/South 1999b

Gillnet sets were done using "standard gang" nets consisting of a series of nets of different mesh size strung out over a width of river. CPUE and species composition calculations were done for entire gangnet sets. However, since different mesh sizes tend to catch different sizes and species of fish, an attempt was made to break down the North/South gillnet data further by mesh size. This presented a number of challenges:

?? Consistency in data records was encountered because mesh size was not recorded for all gill net captured fish, therefore, a complete summary of species caught by mesh size could not be conducted.

?? When only data with a corresponding mesh size recorded were used, sample size became insufficient to allow meaningful statistical analyses (Table 6E-15).

A total of 206 fish representing 16 species were caught within the study area in 70 gillnet sets during February, March, July, and September of 1999. Catch per unit effort was highest in July when an average of 11.1 fish were caught per 24-hour period. Species diversity was highest at in both March and

July when 13 species were caught in the study area, and lowest at in February, when only five different species were caught. The most abundant species in gillnet catches was goldeye, followed by sauger and channel catfish.

The sample size and completeness of the catch by mesh size for Zone 3A were sufficient to allow statistical analysis of that zone (Table 6E-17). From the pooled data, mesh sizes 1.5 and 2 captured the largest diversity of species (Table 6E-16).

TABLE 6E-16

NUMBER OF SPECIES CAUGHT IN EACH MESH SIZE

	Mesh 1	*Mesh 1.5*	*Mesh 2*	*Mesh 3*	*Mesh 3.75*	*Mesh 4.25*	*Mesh 5*
Zone 1	0	3	3	3	2	3	4
Zone 2	3	7	6	3	1	5	2
Zone 3	0	0	0	0	0	0	0
Zone 3A	0	5	6	2	2	3	5
Zone 4	0	2	1	0	0	1	1
Zone 5	0	0	0	0	0	0	1
Total	**3**	**17**	**16**	**8**	**5**	**12**	**13**

Data source: North/South 1999b

5.0 FISH CATCH- GENERAL DISCUSSION

The 1999 fish sampling on the Red and Assiniboine Rivers, North/South data has been compared to another extensive study of fish in the Red and Assiniboine Rivers conducted by Clarke *et al.* (1980) in 1972 to 1974.

Clarke *et al.* (1980) caught 35 species of fish and lamprey in his 1972-1974 study; 20 species by hoopnet, and 18 species by gillnet. The 1999, study caught 18 species using hoopnetting techniques, and 16 species of fish using gillnetting techniques. Historically, 66 species of fish have been identified in the Red River (Appendix 6D, Table 1).

In the hoopnetting portion of the 1999 study, CPUE and species diversity peaked in August (Remnant *et al.* 2000), contrary to July as found by Clarke (Clarke *et al.* 1980 in Remnant *et al.* 2000). In the 1999 study the average CPUE and species diversity increased as one progressed downstream on both the Red and Assiniboine Rivers, however, CPUE was consistently higher in the Red River. In terms of gillnetting, CPUE for the 1999 study peaked in July, however it should be noted here that no gillnetting was done in August (Remnant *et al.* 2000).

In 1999, the hoopnet catch was dominated by channel catfish (Remnant *et al.* 2000), as was also the case in Clarke's study. Clarke *et al.* (1980) found that channel catfish were highly mobile and used both the Red and Assiniboine River systems. Hoopnet and gillnet data from the Clarke *et al.* study also showed that some channel catfish moved upstream for the winter while others moved downstream, and still others remained within the city limits. Clarke *et al (1980).* floy-tagged catfish were found as far upstream as Halstad, Minnesota, as far downstream as West Dogwood Point in Lake Winnipeg, and as far upstream on the Assiniboine River as Portage La Prairie (Clarke *et al.* 1980). The conclusion by Clarke *et al* (1980)that channel catfish are highly mobile was supported by acoustic tagging done by Barth and Lawrence (2000) who found that 45% of their acoustic-tagged channel catfish moved downstream to over winter, 20% moved upstream, and 25% overwintered in Winnipeg, while 10% appeared to have left the study area.

Seasonal movements are speculated for a variety of species by Clarke *et al.* (1980) and by Remnant *et al.* (2000), however both concede it is difficult to draw any conclusions as hoopnetting tends to catch only fish bound upstream (Remnant *et al.* 2000), and both the 1980 and 1999 studies were not consistent with time, gear and location over any length of time. In the 1999 North/South study no gillnetting was done in August, yet gillnetting data include winter netting whereas no hoopnetting was done in the winter months. Also, the 1999 study was conducted for only one year, (as opposed to three years for 1989 study) and was done during a time of irregularly high stream flow (Remnant *et al.* 2000). Any of the above irregularities and inconsistencies may account for differences between Clarke *et al* (1980) study and 1999 study.

6.0 BENTHIC INVERTEBRATE DATA

Raw data (Tetr*ES* 2002) on benthic invertebrates in the Red and Assiniboine Rivers were also re-analyzed by TetrES Consultants Inc. A segment-by-segment analysis for each species has been conducted. Densities of common invertebrate indicators *Ephemeroptera* and *Oligochaeta* have been illustrated segment by segment for both rivers for the winter and fall 1999 study periods (Figures 6E-9 to 6E-16).

When examining invertebrate samples it was noted that three benthic samples were obtained at each site, archived one and two, and labeled. A statistical analysis requires, three data points, therefore the 2 invertebrate counts for each segment were averaged and the average was used as an estimated third sample. Using these three numbers, a proxy best case standard deviation could be calculated. In most cases, the standard deviation equalled or exceeded the mean indicating that invertebrate communities on both the Red and Assiniboine Rivers were so variable that no conclusions could be drawn.

It was not possible to compare invertebrate catch with the substrate data provided in Davies and Zrum (2000) which states that they sought out only soft and medium substrates in order to ensure that a sample would be retrievable, and no substrate type was listed in benthic data tables, only a verbal description of the terrain. Only general location descriptions relative to other net sites or grab sites were indicated. As a result, overlaying benthic data on the GIS substrate map is not possible.

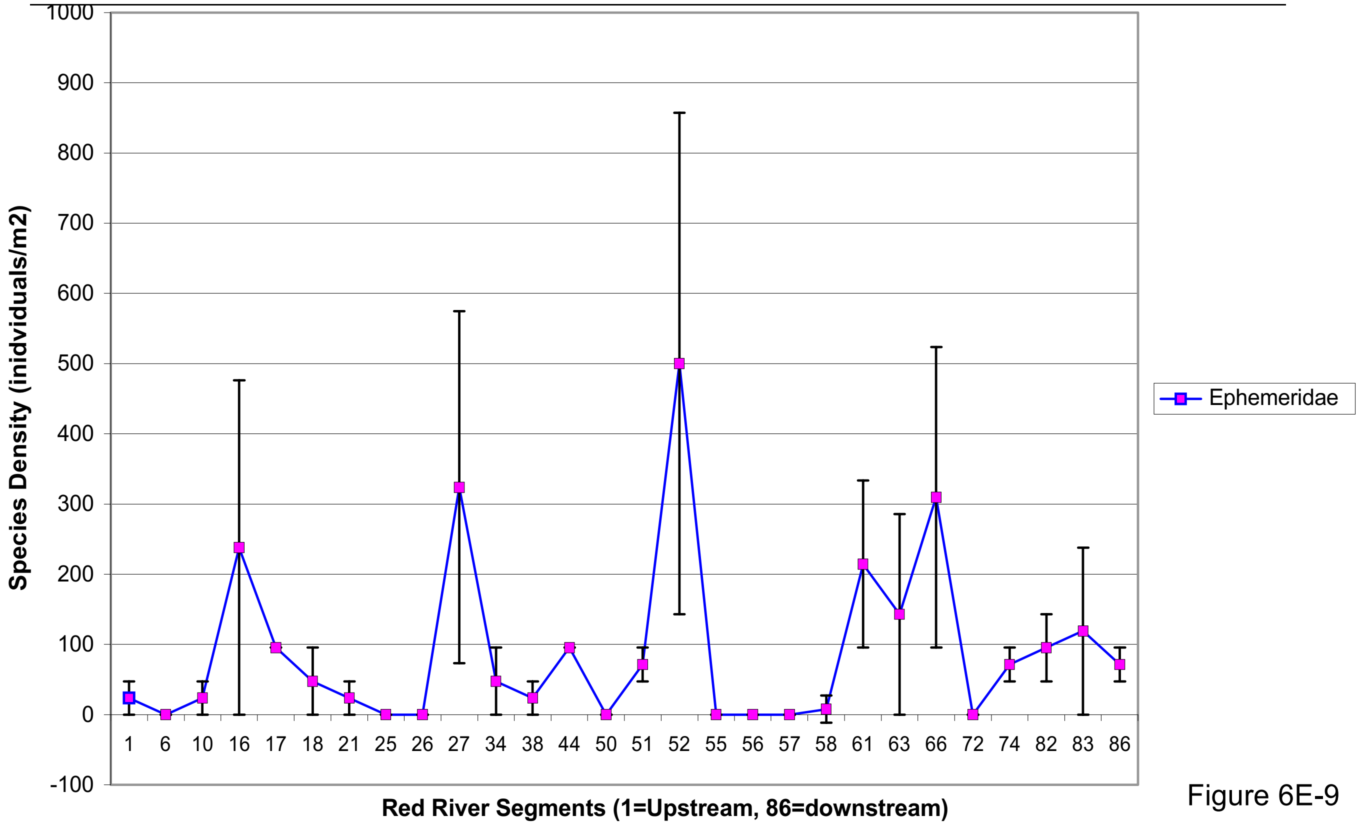


Figure 6E-9

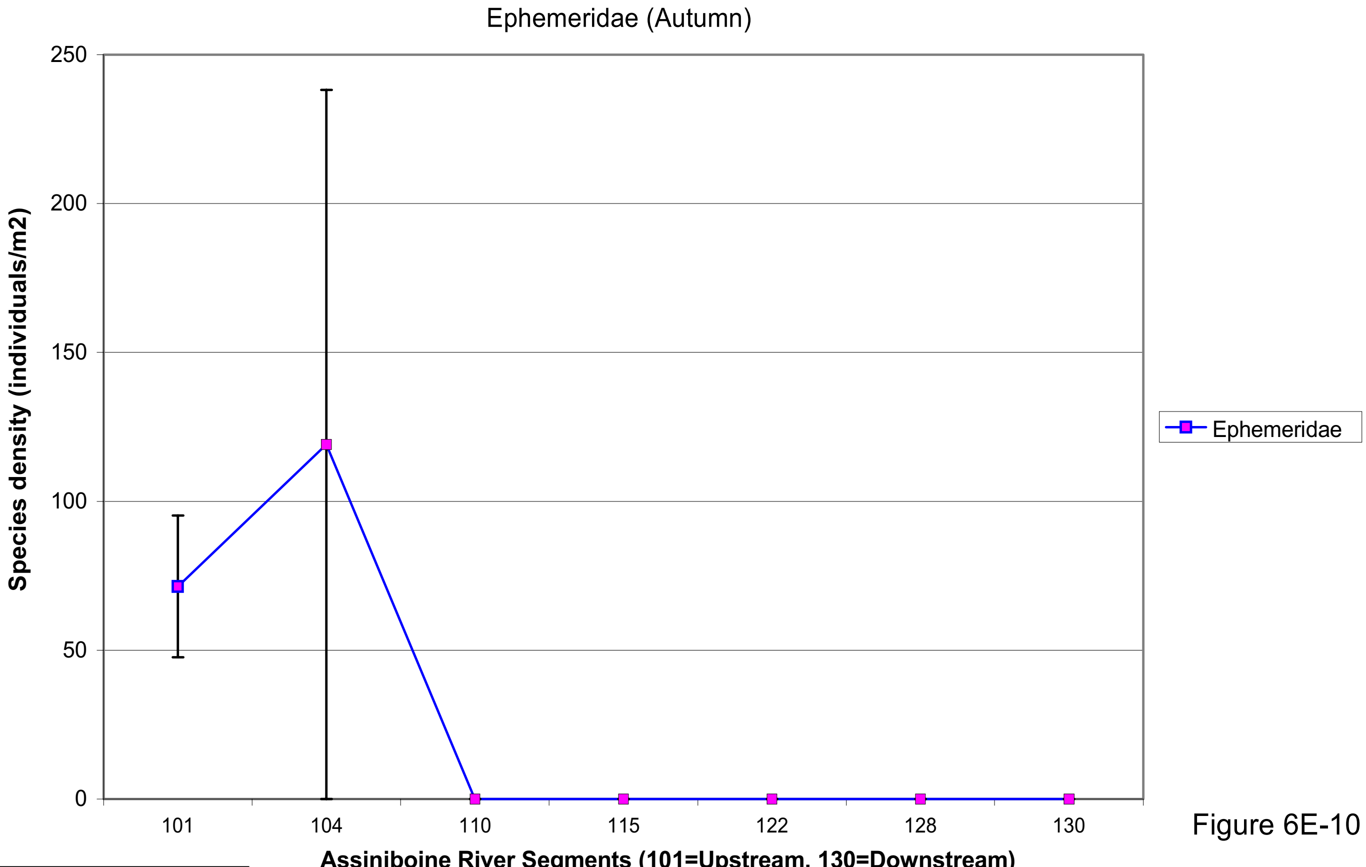


Figure 6E-10

I - standard deviation

benthic1
ms\01\0211\09

Data Source: North / South 1999b

Density of Empheridae sp. in the Red and Assiniboine Rivers in the Autumn of 1999

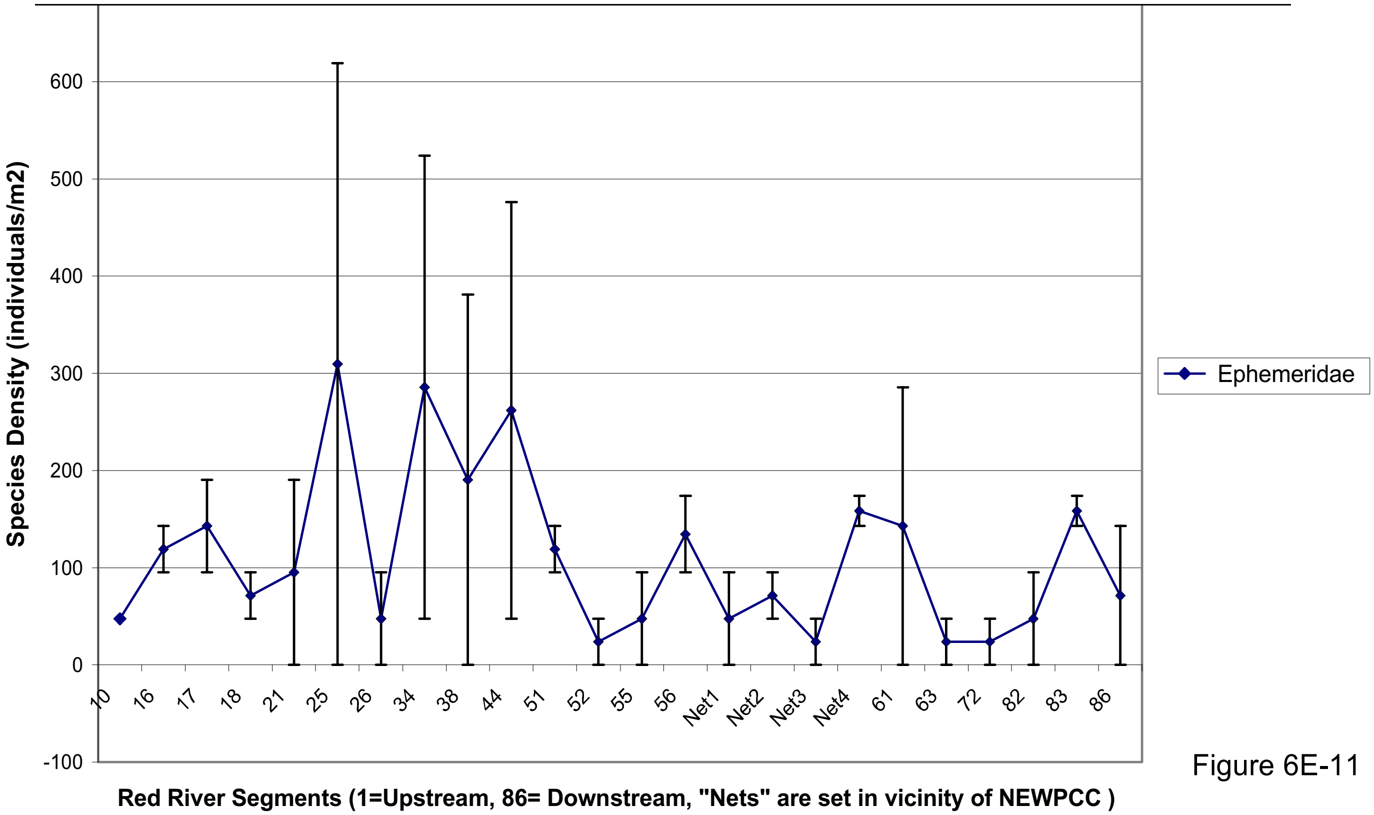


Figure 6E-11

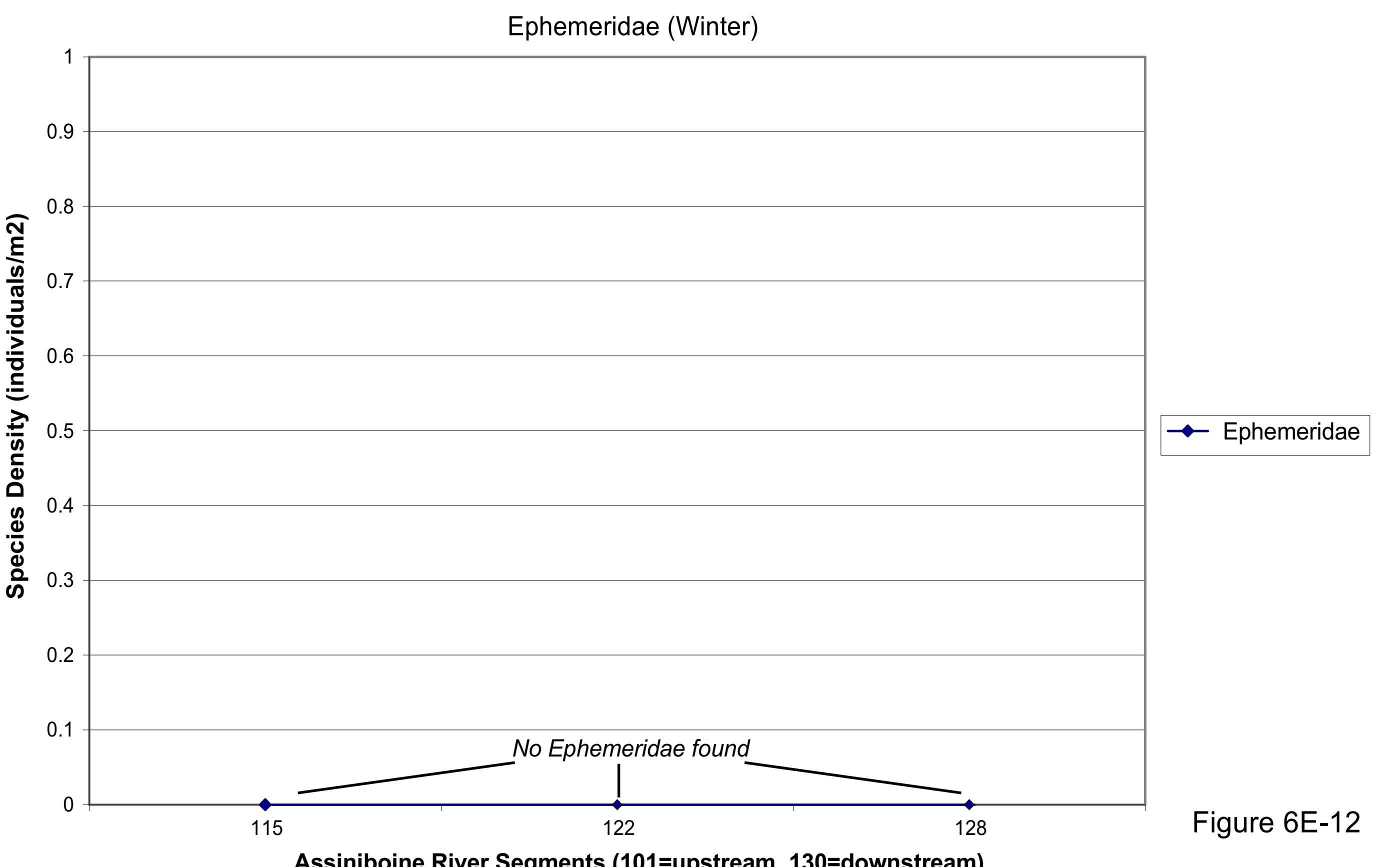


Figure 6E-12

- standard deviation

benthic2
ms\01\0211\09

Data Source: North / South 1999b

Density of Empheridae sp. in the Red and Assiniboine Rivers during Winter (Feb and Mar) 1999

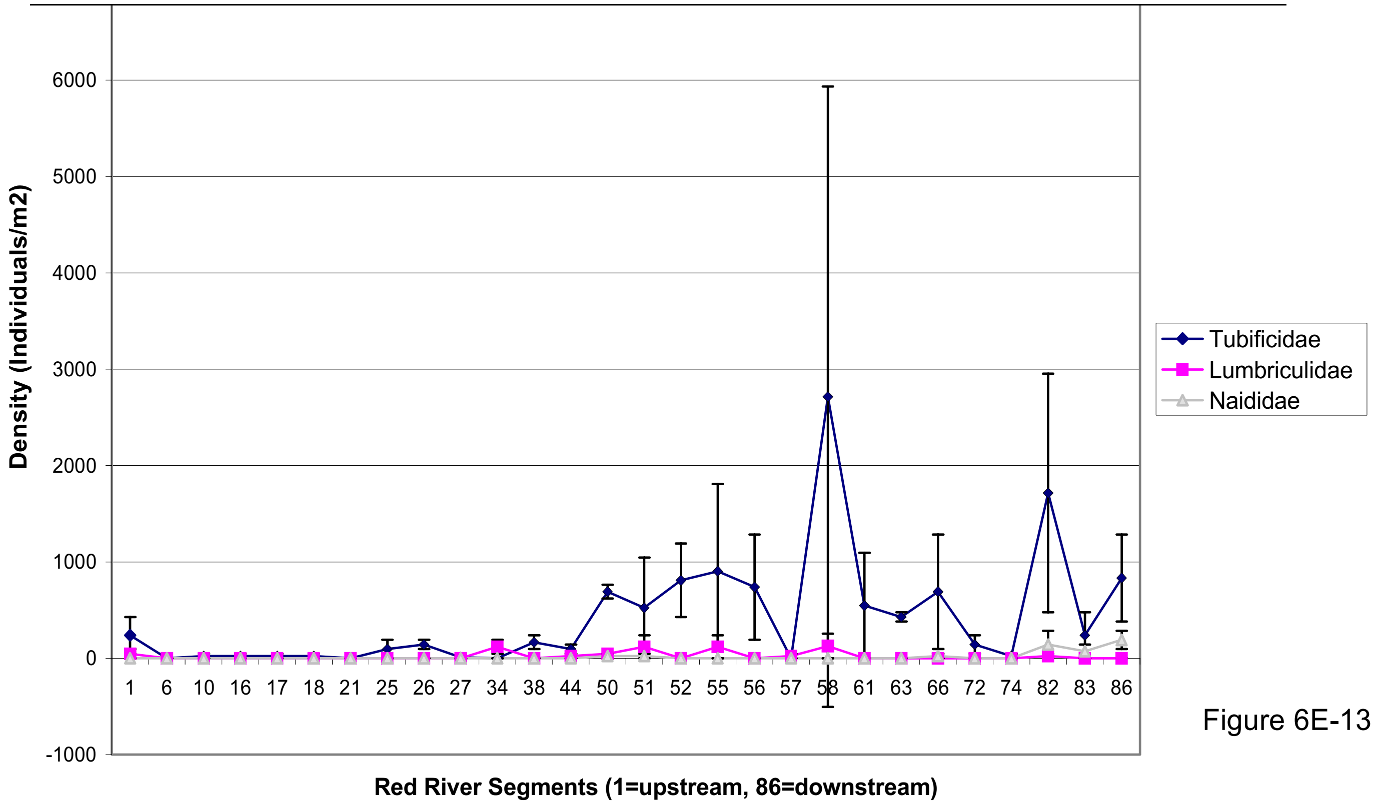


Figure 6E-13

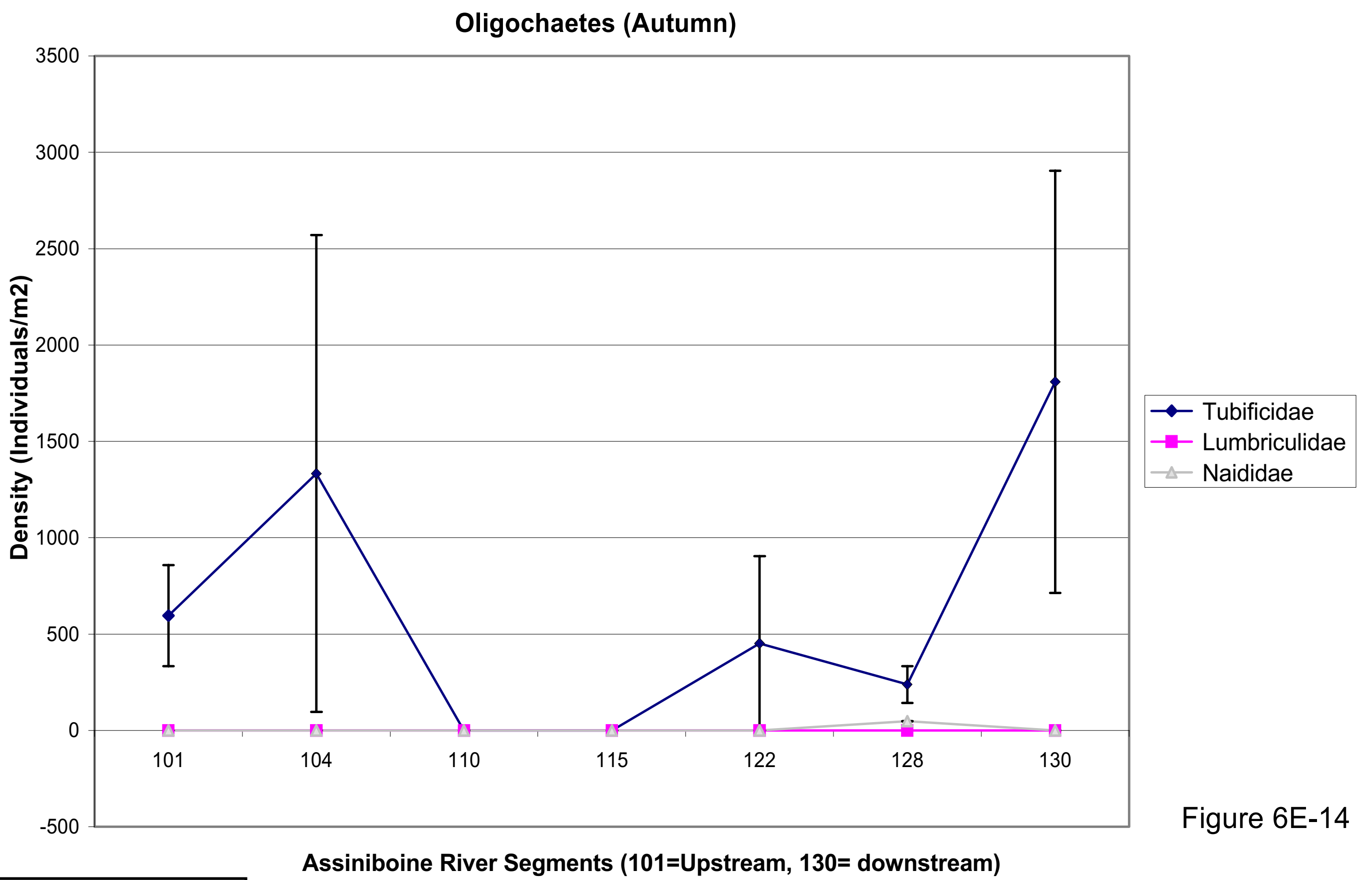


Figure 6E-14

I - standard deviation

benthic3
ms\01\0211\09

Data Source: North / South 1999b

Density of Three Species of Oligochaetes in the Red and Assiniboine Rivers during Autumn 1999

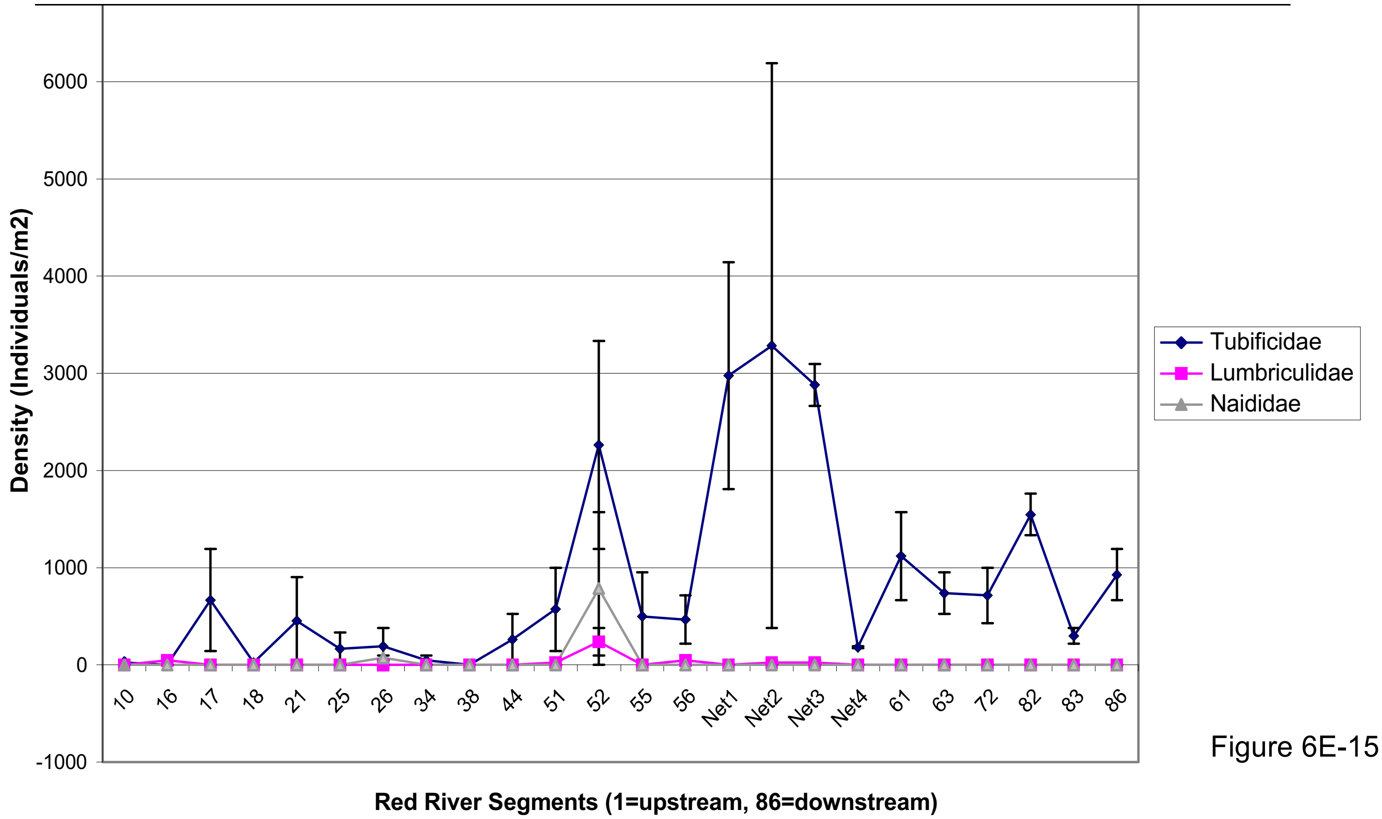


Figure 6E-15

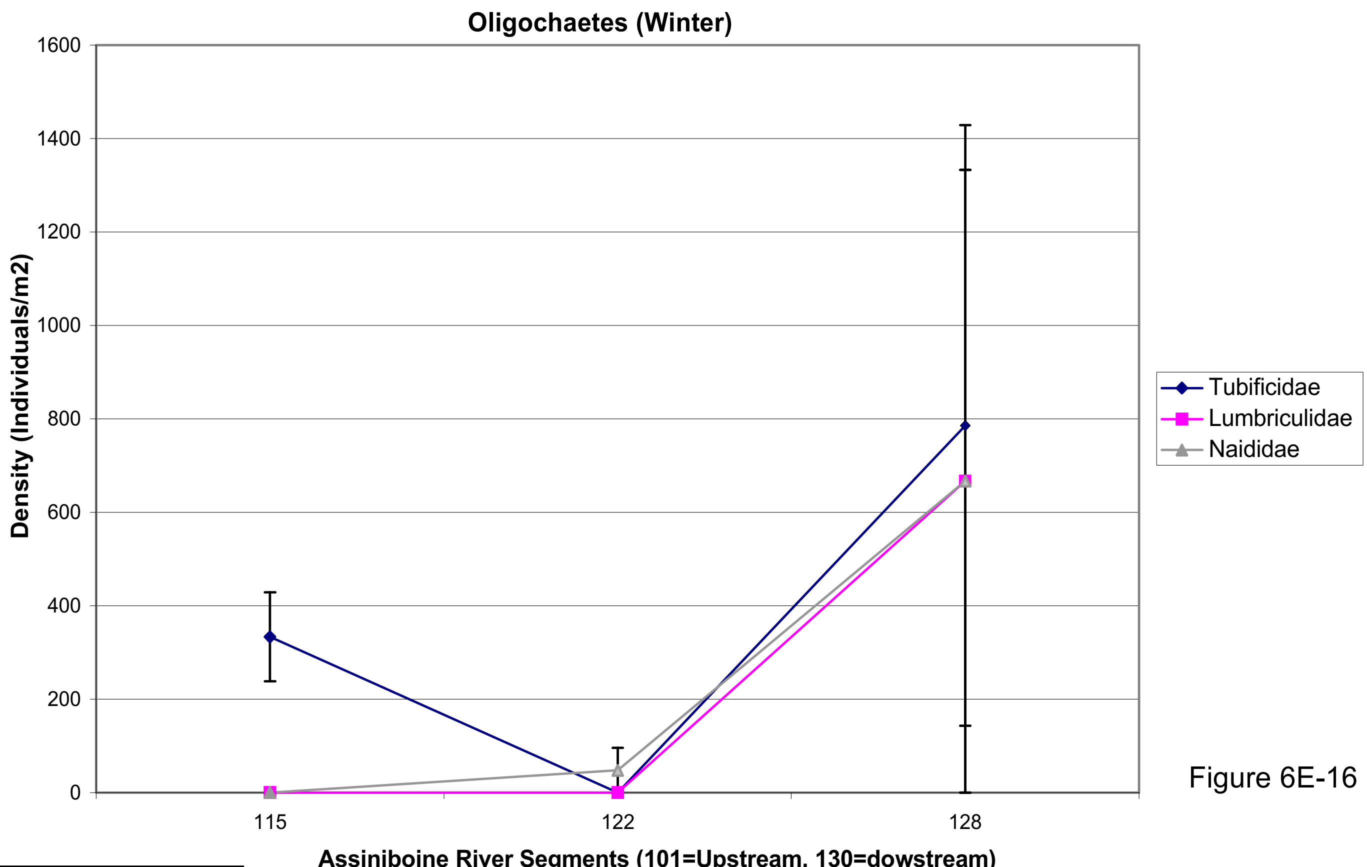


Figure 6E-16

I - standard deviation

benthic4
ms\01\0211\09

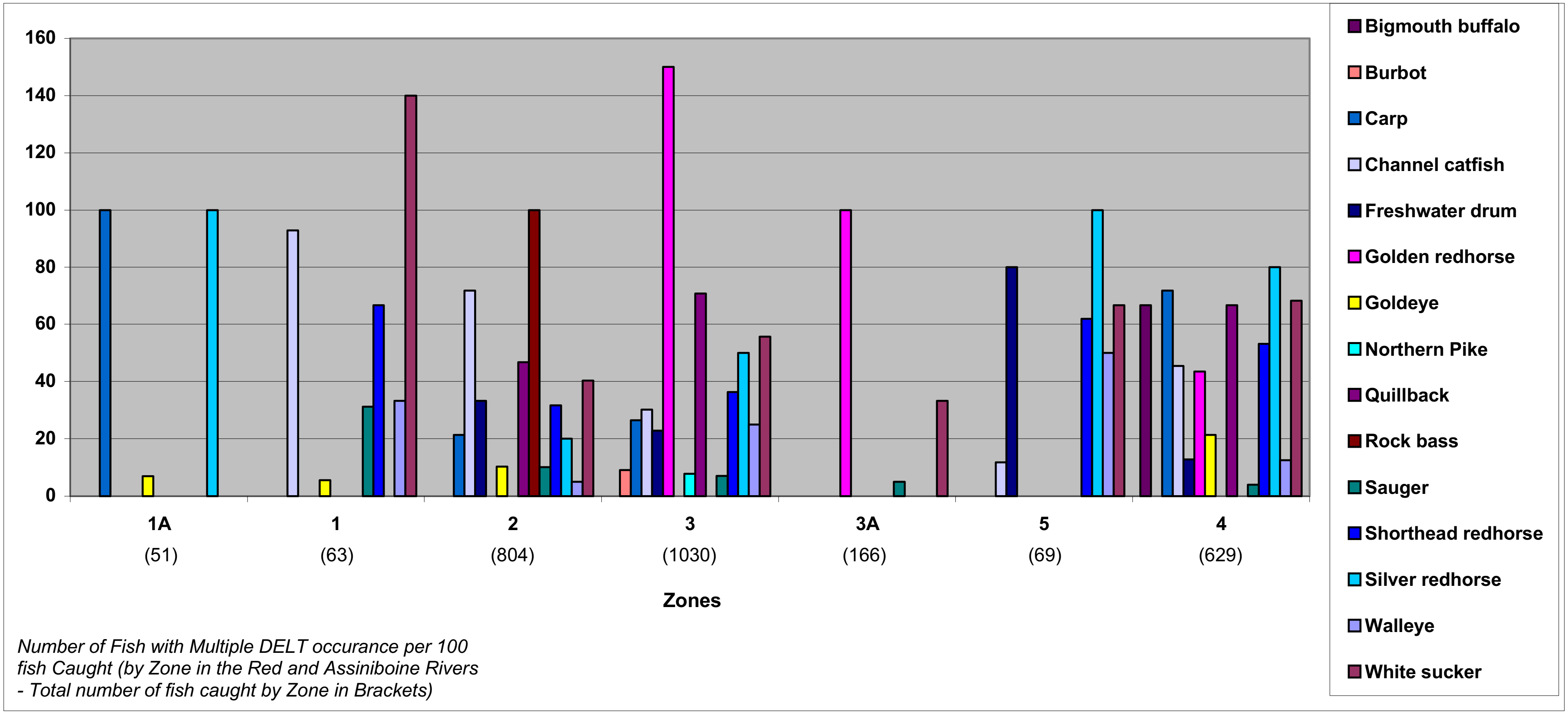
Data Source: North / South 1999b

Density of Three Species of Oligochaetes in the Red and Assiniboine Rivers during Winter 1999

7.0 DELT DATA

During the 1999 fish sampling studies on the Red and Assiniboine Rivers in all fish caught were examined for evidence of deformities, erosions, lesions, and tumours (DELTs) (Cooley and Davies 2001). The 1999 study recorded the length and weight measurements for each fish that exhibited DELTs, along with a description of each DELT, date, location and method of capture. The 1999 study included mention of all external regularities, but did not count scale disorientation, haemorrhaging or parasites as a DELT. It must also be assumed that the 1999 study did not count as DELTs any damage caused by the gillnetting or hoopnetting procedure. The 1999 study also separated DELT data between fish that exhibited one DELT and fish that exhibited multiple DELTS.

The North/South data were summarized to show the occurrence of DELTs per 100 fish per species per zone for both single DELT and Multiple DELT situations (Tables 6E-18 and 6E-19 and Figures 6E-17 to 6E-32). When examining the frequency of DELTs found in the study, it was found that one or more DELTS were found on 15.6% of fish found in the Assiniboine, and 7.9% of fish found in the Red River (Cooley and Davies 2001) but when examining this phenomena when individual species are considered, it is found that DELT s are found predominantly in bottom dwelling fish such as quillback, channel catfish, white sucker, shorthead redhorse, golden redhorse, carp and freshwater drum (Cooley and Davies 2001).



Data Source: North / South 1999b

Distribution in Zones of Fish by Species in the Red and Assiniboine Rivers Who Displayed Multiple DELTS

Figure 6E-17

delts
ms\01\0211\09

Figure 6E-18 **Bigmouth buffalo**

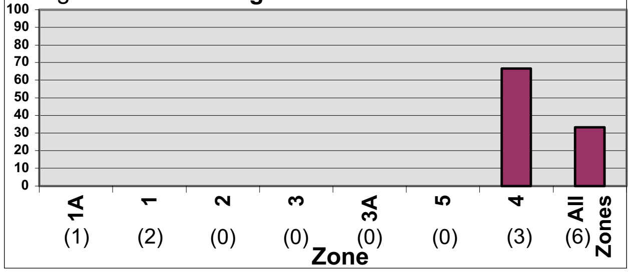


Figure 6E-19 **Burbot**

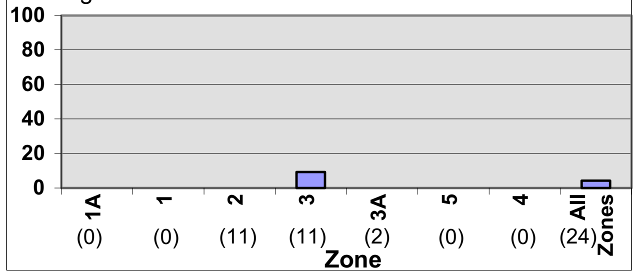


Figure 6E-20 **Carp**

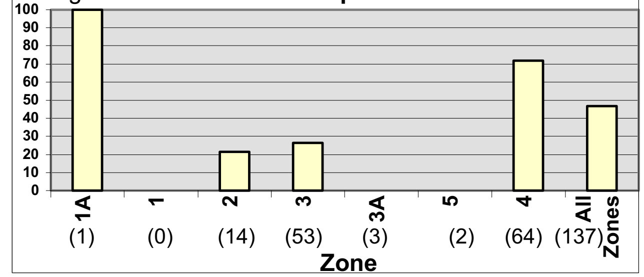


Figure 6E-21 **Channel catfish**

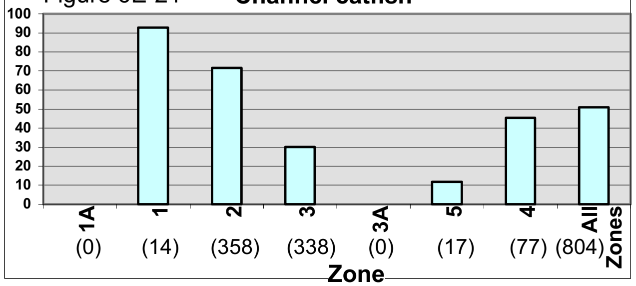


Figure 6E-22 **Freshwater drum**

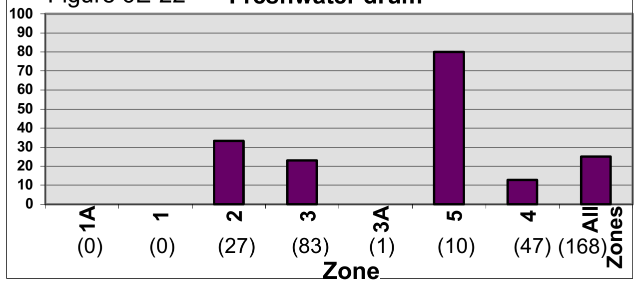


Figure 6E-23 **Golden redhorse**

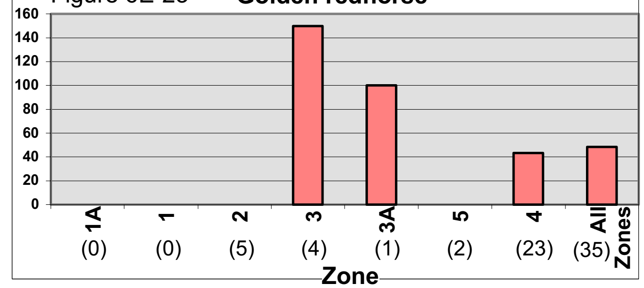


Figure 6E-24 **Goldeye**

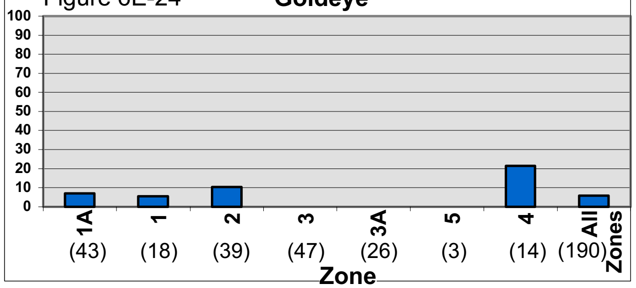


Figure 6E-25 **Northern Pike**

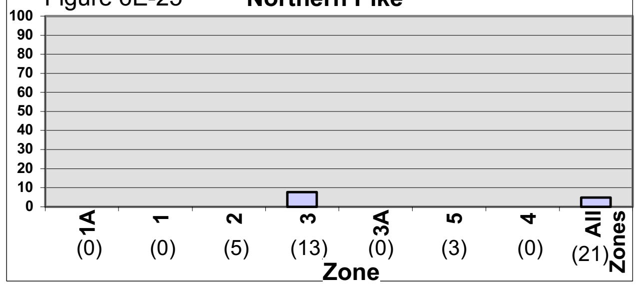
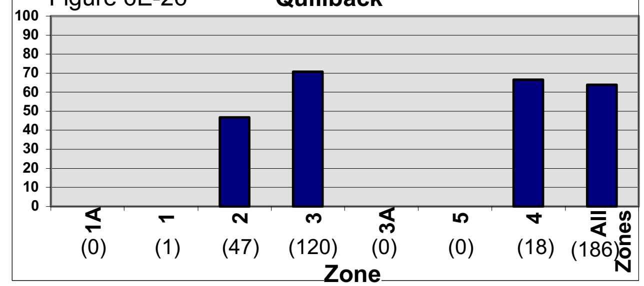


Figure 6E-26 **Quillback**

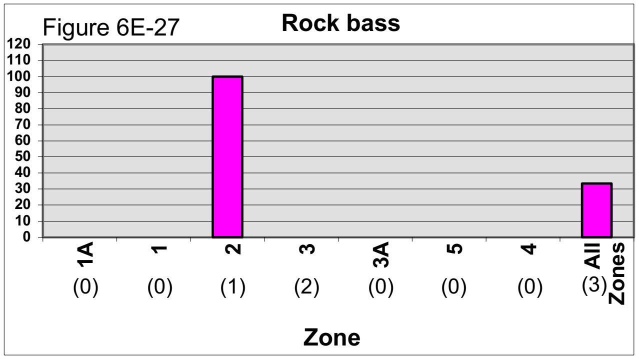


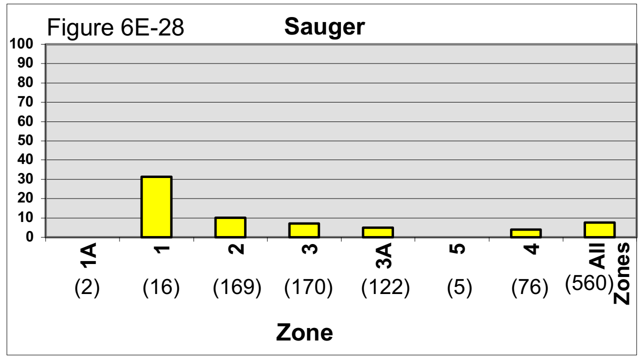
Data Source: North / South 1999b

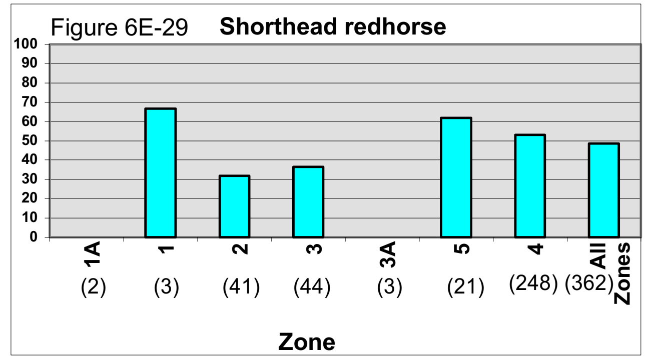
Number of DELT Occurences or Anomalies per 100 Fish Caught (by Zone in the Red River [Zone 1a, 1, 2,3 & 3A] and Assiniboine River [Zones 5 &4] - Total Number of Fish Caught in Brackets)

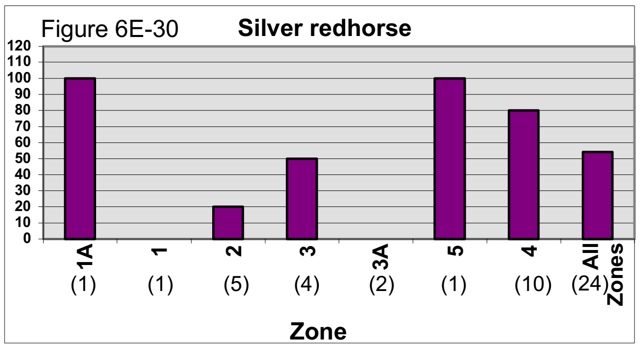
Figures 6E-18 to 6E-26

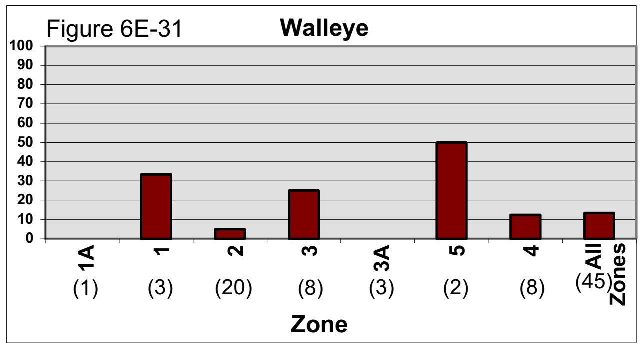
delt2
ms\01\0211\09

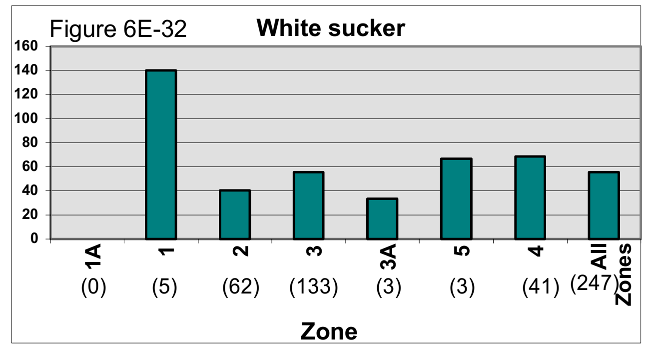












Data Source: North / South 1999b

Number of DELT Occurences or Anomalies per 100 Fish Caught (by Zone in the Red River [Zone 1a, 1, 2,3 & 3A] and Assiniboine River [Zones 5 &4] - Total Number of Fish Caught in Brackets)
Figures 6E-27 to 6E-32

delt3
ms\01\0211\09

TABLE 6E-18

NUMBER OF FISH WITH ONE DELT OCCURENCE PER 100 FISH CAUGHT BY ZONE IN THE RED AND ASSINIBOINE RIVERS, 1999

Species	Zone						
	1A	1	2	3	3A	5	4
Bigmouth buffalo	0	0	0	0	0	0	33
Burbot	0	0	0	9	0	0	0
Carp	0	0	7	11	0	0	44
Channel catfish	0	14	4	3	0	6	13
Freshwater drum	0	0	11	13	0	80	6
Golden redhorse	0	0	0	25	0	0	17
Goldeye	2	0	3	0	0	0	14
Quillback	0	0	28	26	0	0	33
Rock bass	0	0	100	0	0	0	0
Sauger	0	19	5	2	1	0	3
Shorthead redhorse	0	33	12	9	0	24	12
Silver redhorse	0	0	20	25	0	100	30
Walleye	0	0	5	13	0	50	0
White sucker	0	60	16	20	0	33	12
Fish Species with No DELTs recorded							
Black bullhead	0	0	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0
Brown bullhead	0	0	0	0	0	0	0
Mooneye	0	0	0	0	0	0	0
Northern Pike	0	0	0	0	0	0	0
Stonecat	0	0	0	0	0	0	0

Data source: North/South 1999b

TABLE 6E-19

NUMBER OF FISH WITH MULTIPLE DELT OCCURENCES PER 100 FISH CAUGHT BY ZONE IN THE RED AND ASSINIBOINE RIVERS, 1999

Species	Zone						
	1A	1	2	3	3A	5	4
Bigmouth buffalo	0	0	0	0	0	0	67
Burbot	0	0	0	9	0	0	0
Carp	100	0	21	26	0	0	72
Channel catfish	0	93	72	30	0	12	45
Freshwater drum	0	0	33	23	0	80	13
Golden redhorse	0	0	0	150	100	0	43
Goldeye	7	6	10	0	0	0	21
Northern Pike	0	0	0	8	0	0	0
Quillback	0	0	47	71	0	0	67
Rock bass	0	0	100	0	0	0	0
Sauger	0	31	10	7	5	0	4
Shorthead redhorse	0	67	32	36	0	62	53
Silver redhorse	100	0	20	50	0	100	80
Walleye	0	33	5	25	0	50	13
White sucker	0	140	40	56	33	67	68
Species with no DELTs and Anomolies caught by Zone on the Red and Assiniboine Rivers							
Black bullhead	0	0	0	0	0	0	0
Black crappie	0	0	0	0	0	0	0
Brown bullhead	0	0	0	0	0	0	0
Mooneye	0	0	0	0	0	0	0
Stonecat	0	0	0	0	0	0	0

Data source: North/South 1999b

It appears that overall DELTs occurance increased in frequency from Zone 1A to Zone 2 in the Red River, then decrease slightly in Zone 3 and dramatically in Zone 3A. Low DELT frequency in Zones 3A and 1A may be attributable to high concentration of goldeye and sauger in the catches here, species that generally exhibit fewer DELTs. Data also show a higher prevalence of DELTs in fish caught in the Assiniboine River. It is possible that something in Zone 2 and 3 and something in the Assiniboine River may be causing high levels of chronic stress. However, this trend is not apparent for all species.

Upon closer examination of the data, it is also interesting to note that spikes in DELT frequency almost always correlate with a situation where less than 10 (often only one) fish of that species have been captured in that zone. Thus, having 100% of one fish in an area having a DELT cannot confidently act as a representative of the DELT frequency in that zone.

8.0 DESCRIPTION OF THE ALGAE COMMUNITY IN THE RED RIVER

Over 200 of species of plankton occur in the Red River (Tetr*ES* 2001), and are generally grouped as either Zooplankton or Phytoplankton. Zooplankton are generally animal-like, whereas phytoplankton are plant-like. Phytoplankton are typically referred to as algae.

Six main types of algae occur in the Red River: Blue-Green Algae (Cyanobacteria)[1], Green Algae (Chlorophyta), Diatoms (Bacillariophyta), Euglena (Euglenophyta), Silicoflagellates (Chrysophyta), and Crypotophyta (Tetr*ES* 2001). A 1999 study conducted by Tetr*ES* Consultants Inc. reported that by volume, the Red River's algae populations consists of ~48% Green Algae, ~42% Diatoms, ~8% Blue-Green Algae, and ~2% Cryptophyta. All other algae and zooplankton make up less than 1% of the volume of plankton in the Red River. The above percentages are based on measurements taken through the summer and fall of 1999 (Tetr*ES* 2001).

Each species of algae has a period of accelerated growth or "bloom" season in which the population booms, then dwindles as another species increases. Algae species ratios and total amounts of algae are dependent on light penetration, temperature, pH and water chemistry. Therefore total algae varies seasonally and annually. Any point sample may produce very different ratios and species compositions depending on the temporal and physical variables present at the time of sampling.

9.0 REFERENCES

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[1] While it is common practice to include Blue-Green Algae in algae counts, the name is actually a misnomer as this species is in the Kingdom Monera which includes all bacteria, while all the other algae mentioned are from the Kingdom Protista.

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APPENDIX 6F - A

Literature Review of Fish Stranding in Small Streams

1.0 BACKGROUND

In conducting a literature review regarding fish stranding and the implications therein, most of the available reports are regarding flooding and dewatering in impoundments and reservoirs. Some studies have been done regarding intermittent/ephemeral streams and sloughs.

Any natural water body will experience fluctuations in water levels over the course of a year. Spring runoff raises water levels in creeks and streams first, followed by rising water levels in larger channels, usually concurrent with a drop in water levels in the feeder streams (Robinson *et al*. 1998). Stream flows usually then drop-off throughout the summer. Life cycles of native fish follow the ebb and flow, timing their reproductive, feeding, and migratory cycles to correspond with signals from nature (Rogers and Bergersen 1995).

As the preponderance of controlled water bodies increases, issues of how to manage water levels in a way that will benefit humans and wildlife flora and fauna arise. Changes in water levels, and the fluctuations around that new level affect the littoral zone fauna directly through stranding and desiccation, and indirectly via changes to the substrate and available edge ecosystems that support vegetation and invertebrates (Hunt and Jones 1972). In fact, it has been shown that rapidly varying water levels have extirpated large numbers of invertebrates from a water body, and caused population explosions in a few select species for decades after a control structure has been introduced (Hunt and Jones 1972). Fluctuating water levels also contribute to unstable near-shore habitat, habitat that is critical for fish spawning and rearing (Robinson *et al.* 1995).

2.0 EFFECTS OF RAISING WATER LEVELS

Gradually rising water levels in the spring inundate terrestrial vegetation, thus increasing available fish habitat and cover, and enhancing nutrients and overall productivity as the vegetation decomposes (Miranda *et al*. 1984). Invertebrates are also attracted to the flooded vegetation (Hunt and Jones 1972), providing a food source for fish. Flooded terrestrial vegetation in spring promotes rapid growth of young fish (Miranda *et al.* 1984) and early survival of young-of-year (YOY; Miranda *et al*. 1984), especially for shoreline-dwelling fish, and nest- building species like crappies, bass, and sunfish (Meal and Miranda 1991). Flooding rocky areas with little vegetation in spring promotes spawning in walleye and white suckers (Groen and Schroeder 1978, Corbett and Powels 1986). Flooding terrestrial vegetation also likely reduces predator success because of the reduction in predator-prey interaction caused by increased cover and larger substrate area (Miranda *et al*. 1984).

The benefits of increased water levels in spring to YOY fish may be temporary if the increase in food availability in the particular inundated waterbody does not remain sufficient to sustain the numbers of growing fish present (Miranda *et al*. 1984) and though numbers increase, growth slows, so total biomass remains the same unless the carrying capacity and food availability also increase (Miranda *et al*. 1984). Also, after inundated shoreline vegetation decomposes, the inundated vegetation habitat that was created disappears, unless water is drawn down and the shoreline vegetation is allowed to re-establish (Groen and Scroeder 1978).

Sudden increases in water levels or flow rates can be detrimental to fish in certain conditions. Flooding during spawning season can dislodge eggs, bury them in sediment (Meal and Miranda 1991), or wash larvae down stream (Robinson *et al*. 1998). Though sunfish species typically stay near their hatching areas, others like darters, cyprinids and catostomids (suckers) cross the stream currents to reach their rearing grounds (Floyd *et al*. 1984), making them vulnerable to drifting. Some drifting is useful to fish, allowing fish to take advantage of stream flows for dispersal or foraging (Franzin and Harbicht 1992). The fry of some species, such as walleye, may drift as darkness falls and will stop drifting at dawn (Franzin and Harbicht 1992), however drifting may also remove fish to unfavourable habitats.

In order to avoid accidental displacement, fish prone to drifting seek out areas in the stream where flow is slower, such as depressions, coves or near-shore areas sheltered by lots of vegetation (Robinson *et al*. 1998). These resting areas often serve as nurseries or rearing areas for fish larvae, but are also more likely to form stranding ponds if water levels suddenly drop.

Small fish, less effective swimmers, and injured fish are more prone to accidental transportation than others (Robinson *et al*. 1998). In general, fish below 10mm in size are prone to drifting in streams where flow is more than 2 m/s. Drifting decreases rapidly when fish are 10-25 mm and larger (Harvey 1987). Some species remain susceptible even at larger sizes, such as centrarchids, and to a lesser extent, cyprinids (Harvey 1987). Perch and walleye less than 9.5 mm cannot hold their position in water faster than 3 cm/sec (Houde 1969 in Harvey 1987). White sucker larvae drift 11-13 days longer after hatching than walleye (Corbett and Powles 1986). With sustained high flows, almost complete displacement of fish fry can take place, often resulting in complete mortality of transported fish; however recolonization further downstream may take place (Harvey 1987). Flood events occurring after fish have had a chance to reach 10mm in length have been shown to significantly increase survival of fish progeny (Harvey 1987).

3.0 CONCERNS WITH DEWATERING RESULTING IN FISH STRANDING

Dewatering occurs naturally in small streams and can be mimicked by control structures in managed waterbodies. Drawdowns, as with floods, can have both positive and negative effects on aquatic fauna. Gradual drawdowns reduce available substrate, and therefore littoral[1] habitat diminishes: this allows predator fish more access to forage fish that have been forced from the cover of shoreline vegetation, which will help regulate the populations of both since predator and prey species numbers tend to be correlative (Groen and Schroeder, 1978). Rapid drawdowns, on the other hand, may uncover nests and desiccate eggs or larvae trapped in the exposed macrovegetation, and can interrupt spawning activities. If human control of water levels is creating spawning habitat, then care should be taken to not change water levels rapidly.

[1] Littoral – pertaining to the shallow zone near shore where rooted vegetation is commonly found.

Water level drawdowns can fragment habitat, stranding fish in coves, ponds, or sloughs created when water levels decrease enough to cut off access from the main channel (Brown 1985). Fish most likely to be stranded would be those attracted to deepwater refugia as adjacent areas become too shallow and eventually dry up. Small fish, or less effective swimmers take advantage of slower moving "slackwater" along the banks (Robinson *et al.* 1998), and therefore likely favour low-flow, deep-water refugia as well. Predatory fish likely also take advantage of these ponds due to the density and entrapment of prey species. For example, Casselman (1978) found during his study that nets containing northern pike nearly always contained perch, their main prey, indicating that pike actively seek out areas of high prey density.

Isolated ponds resulting from drawdown (natural or otherwise) can serve to protect fish from predation by other fish (if no predator fish were present when stranding occurred), providing excellent nursery and rearing habitat in some cases (Brown 1985). Fish trapped in slow-moving shallow waters have more time to grow and develop, and may have more chance of survival upon re-entering the main channel when the opportunity occurs (Robinson *et al*. 1998). Off-stream habitats (e.g., isolated ponds) can also serve as population stabilizers, buffering catastrophic events in the main stream itself by saving some individuals for later recolonization (Brown 1985, Brown and Hartman 1988). The benefits of stranding or ponding fish, however, rely on the fish eventually rejoining the main channel.

Stranding fish in off-stream sites can also have negative effects, especially in cases where the ponds created are shallow and prone to high temperatures, drops in DO and build ups in toxins from fish wastes and decomposing plant material, which can all suppress foraging and growth (Casselman 1978). Shallow water may cause complete mortality of stranded fish from starvation, over heating, winterkill, or hypoxia[2] (Casselman 1978).

Fish have optimum temperatures and dissolved oxygen concentrations for maintenance of proper growth and health, and also upper and lower limits to water condition parameters. Fish can detect unsuitable temperature and oxygen levels and will move to avoid unfavourable areas (Casselman 1978). For example, DO (dissolved oxygen) preference of white crappies manifests itself as a fidelity to areas with steep banks to allow them access to the 2-3 mg/L DO isopleth with the smallest effort in vertical movement (O'Brien *et al*. 1984 in Markham *et al.* 1991).

Although low DO levels can cause fish mortality in stagnant water (Casselman 1978), some fish species are more tolerant of low levels than others. For example, Casselman (1978) found that northern pike (both in a lab and lake setting) were extremely tolerant to low levels of DO, however, Casselman (1978) found that pike ceased feeding if DO is below 2 ml/L. Casselman found (1978) that northern pike could survive survive through the winter with DO concentrations as low as 0.3 mg/L, and have been found in pockets of water with 0.04 mg/L DO in a lake where maximum DO was 0.8 mg/L. In this same lake, perch (the main prey of pike) were succumbing to hypoxia. In low DO waters where northern pike are present, this low DO tolerant species may have an advantage over those of its prey species that are less tolerant to low DO levels. In general, benthic feeding fish tend to be more adapted to low DO and poor

[2] Hypoxia – a deficiency of available oxygen in bodily tissues.

water quality due to accumulation of contaminants and increased decomposition resulting in low DO near the bottom substrate on which they feed (Vethaak and Rheinallt 1992 in Tetr*ES* 2000).

Most mesothermal[3] fish have an upward lethal water temperature limit of 28-34C (Hokanson 1977 in Casselman 1978). Casselman (1978) found that optimal growth and non-forage related movements of northern pike occurred in a water temperature range of 19-21C, however above the optimal range, growth and movement decreased until both essentially stopped at 28C. Casselman (1978) found that the lethal limit for pike appears to be 29.4C. Casselman (1978) notes that lower optimal temperatures for growth and movement were observed older fish than in sub-adults.

Predatory fish may alter their behaviour in response to dewatering. Large mouth bass have been shown to increase their foraging activity, and travel well out of their home ranges in search of prey in times of drawdown (Heman *et al*. 1969, and Rogers and Bergersen 1995).

If stranded fish manage to survive a summer in a shallow pond, they may still be vulnerable if water levels once again connect them to the main channel. When stranded fish are suddenly inundated with main channel water which may be many degrees cooler than the standing shallow water in an isolated pond, they are susceptible to thermal shock. Thermal shock can cause mortality or an inability to resist drifting or avoid predation (Robinson *et al*. 1998).

4.0 MITIGATION STRATEGIES

The critical element in water level management is timing (Groen and Schroeder 1978). Floods and drawdowns at crucial times such as spawning and rearing should be avoided, at least until young are >10 mm total length. Gradual water level changes, rather than rapid changes, can mitigate detrimental effects to fish.

Deepening existing areas where stranding occurs will not decrease the occurrence of stranding, but may serve to make the pond deep enough to avoid winter kill, overheating and hypoxia (Brown 1985). If soft substrates are present in these areas, however, the effect would likely be temporary due to sediment in-filling of these deep water refugia (Brown 1985) or may serve to more effectively strand the fishes (Brown 1985). Pond refugia would also have to be deep enough such that sufficient open water pockets remain under ice cover during winter.

In some cases, natural inflow to stranding ponds via ground water up-welling or bank release may oxygenate the water or slow DO loss sufficient to maintain fish populations (Becker and Neitzel 1985). As well, an impermeable layer beneath the substrate may serve to hold water and maintain flow across shallow gradients, thus keeping water flowing and oxygenated (Becker and Neitzel 1985). The addition of gravel or rocks to the channel may help to aerate moving water and improve fish habitat by providing shelter, cover, and shade (Jakober *et al.* 1998).

[3] Mesothermal – warm, or middle temperature (as compared to tropical or cold water fish).

Strictly managed reservoirs have had increased angling success and have produced strong year classes by:

- gradually increasing water levels in spring and early summer;
- slowly drawing down beginning mid-summer to allow vegetation to re-establish;
- flooding again in fall to enhance waterfowl habitat; and
- drawing down again in winter to set a favourable stage for spring spawning, allow for storage capacity in case of floods, and reduce ice damage to the shoreline vegetation (Groen and Schroeder 1978).

High discharges and rapid water level changes should be avoided if possible (Groen and Schroeder 1978).

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APPENDIX 6F - B

Detrimental Effects of Increased Aquatic Sediment Load on Freshwater Aquatic Life

1.0 INTRODUCTION

The sediment load of a river consists of the particulate matter suspended in and carried by the water, the dissolved material and chemicals carried by the water, and the bed load which is coarse material that is swept along the riverbed by the current.

An increase in total suspended sediments (TSS) can directly affect the aquatic ecosystem by weakening available sunlight and decreasing visibility, thereby shortening the photic zone[1] and altering the thermal gradient of the water (Wilber and Clarke 2001). Increased TSS can also clog breathing and feeding structures of aquatic vertebrates and invertebrates (Newcombe and MacDonald 1991). Once the increased sediment load begins to settle the river bottom can be altered, affecting spawning and early life stages (Reiser and White 1988).

Increased sediment loads can be caused by bottom disturbances such as dredging, passing of large vessels, large storm events, construction, and wave and current action (Wilber and Clarke 2001). Sediment loads can also be increased by addition of material to a water body by road construction, logging, run-off, and bank erosion (Platts *et al.* 1989).

Craig *et al.* (2000) and Newcombe and MacDonald (1991) both assert that there are shortcomings in many studies being done on the effects of suspended sediments on aquatic ecosystems. Many studies alter only the concentration of TSS and make conclusions based on the results, however duration of exposure is also extremely important in determining the effects of suspended sediments, as are the frequency of exposure, ambient water quality, and life stage of the organisms affected (Newcombe and MacDonald 1991). The physical and chemical nature of substrate sediments and water quality will also affect how aquatic organisms react to increased TSS (Craig *et al.* 2000).

Most studies on the effects of TSS on aquatic life are done in lab settings to reduce large numbers of variables that exist in natural settings (Chilton 1991), thereby making application of results to in-situ very difficult (Burkhead and Jelks 2001). In addition, studies use a variety of natural and artificial sediments in their methods. A literature review by Wilber and Clarke (2001) indicates that Fuller's earth, bentonite, sand, clay, fine and coarse granite, volcanic ash, incinerator residue, silt, charcoal, silica and "natural sediments" were all used to perform TSS studies. Craig *et al.* (2000) indicate that chemical make-up, size, density, settling rate and shape (abrasiveness) of particles all play pivotal roles in the effects a suspended sediment will have on aquatic life, therefore different test situations using different types of sediment cannot be directly compared.

It is widely accepted that increasing the sediment load in a water body can have detrimental effects on aquatic life, therefore mitigation procedures and guidelines are in place. Manitoba Water Policies emphasize avoidance of erosion and sediment deposition caused by human activities (Manitoba Conservation 1994). Manitoba's policies on water conservation and drainage encourage moderation of

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[1] Photic Zone- The depth of water which sufficient sunlight can penetrate for photosynthesis to occur.

flows, control and timing of run-off, retention of natural vegetation, and planned construction of drainage to minimize erosion and deposition. Within the policies it is also recognized that construction projects in one area can affect other areas, thus planning should include mitigation measures to minimize such effects.

2.0 EFFECTS OF SUSPENDED SEDIMENTS AND DEPOSITION ON AQUATIC LIFE

2.1 EFFECTS ON ALGAE

As photosynthetic organisms, algae will experience lower growth rates as light penetration decreases due to increased TSS in the water (Newcombe and MacDonald 1991). Prolonged elevated levels of abrasive suspended sediment in fast moving water can also scour algae off the substrate (Newcombe and MacDonald 1991). Nutrients and toxins associated with the sediments can also affect the growth rates and biomass of algae populations (Newcombe and MacDonald 1991).

2.2 EFFECTS ON INVERTEBRATES

Whatever effect increased TSS has on algae will be mirrored in grazing invertebrates that depend on algae for food. Filter feeding invertebrates may experience clogging of their feeding structures and a reduction in feeding efficiency as concentration of suspended sediment increases (Newcombe and MacDonald 1991). Invertebrates may experience damage to their respiratory organs or be dislodged or displaced due to particulate matter in the water (Newcombe and MacDonald 1991).

2.3 EFFECTS ON SHELLFISH

A literature review by Wilber and Clarke (2001) summarizes the effects of increased TSS on various life stages of estuary-dwelling bivalves. Egg development can be adversely affected by abrasion caused by coarse sediments. In a marine environment egg development was slowed by as low as 188mg of silt per litre in the eastern oyster (*Crassostrea virginica*), and up to 1,000 mg/L for the northern quahog (*Mercenaria mercenaria*). Larval development was generally good below 750 mg/L for quahogs and oysters, but mortality occurred in eastern oyster larvae when exposed to concentrations >400 mg/L for 12 days. Adult bivalves cope with increased TSS by reducing their pumping rate, and ejecting excess filtered material (Wilber and Clarke 2001). This coping mechanism affects feeding efficiency by lowering the concentration of their ingested food, thereby reducing growth. To cause mortality adult in bivalves, very high silt concentrations around 10,000 mg/L are required for several weeks, but adverse effects are apparent at much lower concentrations (Wilber and Clarke 2001). For example, softshell clams exhibited reduced gape and reduced response to mechanical stimuli at concentrations as low as 100-200 mg/L suspended sediments for exposure times of less than a month (Wilber and Clarke 2001).

2.4 EFFECTS ON CRUSTACEANS

Twenty-five percent mortality was noted in crustaceans exposed to TSS concentrations greater than 10,000 mg/L, essentially fluid mud, across several studies reviewed by Wilber and Clarke (2001). These results suggest that crustaceans possess a high tolerance to TSS (Wilber and Clarke 2001). Highly turbid water resulting from high TSS concentrations may also provide cover and therefore decrease predation of crustaceans (Wilber and Clarke 2001).

2.5 EFFECTS ON FISH

2.5.1 Spawning Habitat and Early Life Stages

Many studies have been conducted on the effects of increased TSS on salmonid species due to the importance of this group to commercial fisheries, and because salmonids are particularly susceptible to fine particle sedimentation in spawning and rearing habitats (Cordone and Kelly 1961 In: Platts *et al.* 1989). Salmonid eggs and larvae can be smothered by deposition of fine sediments on gravel substrate. Fine sediments may clog spaces among the gravel particles, reducing water velocity along the substrate and limiting oxygen supply and waste removal (Reiser and White 1988 and Reiser *et al.* 1998). Benthic spawning species appear to be the most affected by increased TSS concentrations as deposited sediments can greatly reduce egg survival and suspended sediments can drastically reduce spawning activity particularly in species where visual spawning cues are present (Burkhead and Jelks 2001).

2.5.2 Adult Fish

Fine sediments coat the linings of respiratory organs resulting in oxygen deprivation by decreasing gas exchange or clogging them altogether (Wilber and Clarke 2001). Oxygen deprivation can be quantified by measuring red blood cell, hematocrit, and haemoglobin counts (Wilber and Clarke 2001). Sublethal hematocrit and haemoglobin levels were noted in white perch in TSS concentrations as low as 650 mg/L for 5-day exposures, while resistance to effects was observed in striped bass in TSS concentrations of up to 1,500 mg/L for 14-day exposures (Wilber and Clarke 2001).

Salmonids have exhibited responses to increased TSS such as coughing and gill flaring, increased swimming activity (an alarm response), disrupted schooling, and territoriality (Wilber and Clarke 2001). In salmonids and other fish, a decrease in reaction distance (the distance at which predators see or pursue prey) has been observed as TSS concentrations increase (Wilber and Clarke 2001). Decreased reaction distances lead to decreased feeding thereby affecting survival, year class strength, and overall fish health (Wilber and Clarke 2001).

3.0 SUSCEPTIBLITY

Prolonged exposure and increased TSS concentration both increase the effects of suspended sediments on fish and other life, although some species are more tolerant than others (Wilber and Clarke 2001). Crustaceans are extremely tolerant compared with other groups (Wilber and Clarke 2001). In general, benthic (bottom) dwelling species tend to be more tolerant of high TSS because they are accustomed to higher sediment concentrations (Wilber and Clarke 2001). Adult fish seem to have slightly higher tolerances (duration and concentration) than young fish (Wilber and Clarke 2001).

Motile organisms generally have short exposure times to elevated TSS unless they are enclosed within a confined space (Wilber and Clarke 2001). These short exposure times correspond to a short tolerance time in comparison to non-motile species which are often able to tolerate elevated TSS for several days as they are unable to remove themselves to more favourable environments (Wilber and Clarke 2001).

The potential for TSS-related effects also depends heavily on the nature of the ambient environment such as background TSS levels, water clarity and light transmission (Craig *et al*. 2000). The chemical and physical nature of the disturbed substrate or eroded material also influence the effects of TSS on aquatic life. For example, if the plasticity index of the material is >4, the particles are non-abrasive, and can be tolerated to higher concentrations. A suspended sediment like fine clay, although highly visible, would have less effect on aquatic life than an abrasive or coarse sediment, even after episodic exposures over many months (Craig *et al.* 2000).

4.0 EFFECTS OF THE PROJECT ON TSS AND AQUATIC LIFE

Sediment concentrations in the Red River fluctuate resulting in considerable seasonal and annual variations (Table 4-1). While monthly changes in sediment load can show a similar pattern from year to year, examining sediment load as a function of flow is believed to be a more accurate predictive method for predicting monthly sediment concentration (Brown *pers. comm*. 2004). In general, TSS increases as a function of increased flow. Increased run-off will raise the amount of suspended sediment in a stream through bank erosion and flushing of bottom sediments (Linsley *et al.* 1972). KGS Group conducted a computer model analysis of volume of flow in the Red River vs. TSS concentration (Figure 4-1). Using the model, TSS concentration can be predicted for any given rate of flow.

TABLE 4-1
SEASONAL FLUCTUATIONS IN SEDIMENT LOAD OF THE RED RIVER AT LOCKPORT

Concentration of TSS at Lockport (mg/L) 1958-1992			
Month	**10th Percentile**	**50th Percentile**	**90th Percentile**
January	8	12	25
February	6	11	22
March	8	15	112
April	35	287	825
May	28	140	282
June	29	82	248
July	30	61	230
August	17	39	137
September	16	32	95
October	11	26	76
November	12	23	83
December	9	14	27

Data Source: KGS Consultants 2004

TSS in the Red River downstream of the floodway would only be affected if the Floodway was used during the construction phase. It is therefore necessary to relate increases in TSS not to “normal” background Red River TSS levels during typical flow, but to expected flow levels for given flood events. Using the relationship between flow and sediment load, the KGS model predicted:

1) the sediment load that could be generated by the increased flow of a flood;
2) the amount of additional construction-related sediment load due to erosion if a flood event occurred during the construction phase of the Floodway Expansion (Table 4-2).

A 3.3-year flood is a flood of a magnitude that could be expected to occur every 3.3 years on average. The flood events listed in Table 4-2 decrease in probability, meaning that a flood of 100-year magnitude would be unlikely to occur during the projected four-year construction plan.

Once ‘worst case scenario’ sediment concentrations are calculated, to determine possible detrimental effects to fish and invertebrate species, one can compare the predicted sediment concentration values to lethal limits that are available in the literature. The Department of Fisheries and Oceans (DFO) has published information (Table 4-3) illustrating the risks of increased sediment to fish and their habitat (Birtwell 1999). However the DFO report does not indicate background sediment levels, species

TABLE 4-2
PROJECTED INCREASE IN SEDIMENT CONCENTRATION IN THE RED RIVER DUE TO FLOODWAY EXPANSION

Baseline Sediment Concentration During Flood in the Red River at Lockport (mg/L) (i.e. No Floodway erosion)								
	Scheme A				Scheme B			
Flood Event	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
3.3 Year	297.6	297.6	297.6	297.3	297.6	297.6	297.6	297.3
5 Year	330.1	374.9	361.3	363.7	304.8	332.1	332.5	363.7
10 Year	437.6	496.6	484.4	500.9	307.9	454.2	418.5	481.0
20 Year	492.0	580.7	621.6	615.9	542.4	459.0	428.7	602.8
33 Year	496.7	551.8	756.3	708.7	471.5	463.8	490.2	746.2
50 Year	494.5	643.8	829.7	713.7	502.2	460.9	473.0	826.6
100 Year	476.4	963.8	1047.1	772.1	946.3	621.2	498.3	925.9
Difference in Sediment Concentration on the Red River at Lockport (mg/L) Due to Flooding During Construction								
	Scheme A				Scheme B			
Flood Event	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
3.3 Year	-0.1	-0.1	-1.1	-1.2	-0.1	-0.1	-0.7	-1.2
5 Year	0.0	0.1	-0.1	-0.2	-0.1	-0.1	-0.2	-0.2
10 Year	0.2	0.6	0.2	0.4	0.0	0.2	0.3	0.4
20 Year	0.3	3.9	0.5	21.2	0.0	0.3	0.5	15.7
33 Year	0.3	1.6	0.6	53.4	0.0	0.3	0.6	113.1
50 Year	0.3	9.5	3.5	58.7	0.0	0.3	0.6	145.3
100 Year	0.3	32.0	54.5	49.7	0.0	0.2	0.6	114.0
Projected Maximum Total Sediment Concentration in Event of Flood During Construction								
	Scheme A				Scheme B			
Flood Event	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 1**	**Year 2**	**Year 3**	**Year 4**
3.3 Year	297.4	297.5	296.5	296.2	297.4	297.4	296.9	296.2
5 Year	330.0	375.0	361.2	363.5	304.7	332.1	332.3	363.5
10 Year	437.8	497.2	484.6	501.4	307.8	454.4	418.8	481.4
20 Year	492.3	584.6	622.0	637.1	542.5	459.3	429.2	618.5
33 Year	497.0	553.5	756.9	762.1	471.5	464.0	490.8	859.3
50 Year	494.8	653.3	833.2	772.4	502.2	461.2	473.6	971.9
100 Year	476.7	995.9	1101.5	821.8	946.3	621.4	499.0	1039.9

* At time of peak additional sediment load exiting the floodway

Data Source: KGS Consultants 2004

composition, duration of exposure or the composition of the sediment. All of these variables are very important in determining the effect of increased TSS to fish and other aquatic life (Craig 2000).

TABLE 4-3
LEVELS OF RISK TO FISH AND THEIR HABITAT
WITH CORRESPONDING CONCENTRATIONS OF SEDIMENT

Sediment Increase (mg/L)	Risk to Fish and Their Habitat
0	No risk
<25	Very low risk
25-100	Low risk
100-200	Moderate risk
200-400	High risk
>400	Unacceptable risk

Source: Birtwell 1999

A more relevant method of predicting risk to aquatic fauna would be an examination of known lethal concentrations and durations on individual species (Table 4-4). Ranking of effects of suspended sediments using a value of 1-14 is common in the reviewed literature. Each rank value indicates the effect on a particular species (Table 4-5).

TABLE 4-5
RANKING EFFECTS OF SUSPENDED
SEDIMENTS ON FISH AND AQUATIC

Rank	Description of Effect
14	>80 to 100% mortality
13	>60 to 80% mortality
12	>40 to 60% mortality
11	>20 to 40% mortality
10	0 to 20% mortality
9	reduction in growth rates
8	physiological stress and histological changes
7	moderate habitat degradation
6	poor condition of organism
5	impaired homing
4	reduction in feeding rates
3	avoidance response
2	alarm and avoidance reaction
1	increased coughing rate

Source: Newcombe and MacDonald 1991

TABLE 4-4

LETHAL AND SUBLETHAL EFFECTS OF INCREASED SUSPENDED SEDIMENT FOR VARIOUS AQUATIC LIFE

Organism	Species	Life History Stage	Concentration (mg/L)	Exposure Time (hr)	Stress Rank*	Nature of Effect	Reference
Fish							
Silver Shiner	Notropis photogenis	Adult	1461	48	7	slight reduction in fish numbers	Schubert, Vinikour and Gartman In: Golder 1995
Tricolour shiner	Cyprinella Trichroistia	Adult	0	120	0	no effect	Burkhead and Jelks 2001
Tricolour shiner	Cyprinella Trichroistia	Adult	100	120	NA	10% drop in spawning	Burkhead and Jelks 2002
Tricolour shiner	Cyprinella Trichroistia	Adult	300	120	NA	30% drop in spawning	Burkhead and Jelks 2003
Tricolour shiner	Cyprinella Trichroistia	Adult	600	120	NA	70% drop in spawning	Burkhead and Jelks 2004
Darters	various	Adult	2045	8760	14	darters absent	Vaughn 1979 In: Golder 1995
Centrarchid Family	Centrarchidae	Adult	144.5	720	12	unable to reproduce	Buck 1956 In: Golder 1995
Yellow Perch	Perca flavescens	Larvae	500	4	11	30% mortality	Auld and Schubel 1978 In: Wilber and Clarke 2001
Yellow Perch	Perca flavescens	Egg	1000	4	0	no effect	Auld and Schubel 1978 In: Wilber and Clarke 2002
Mottled Sculpin	Cottus bairdi	Adult	122.5	660	12	59% reduction in #s	Barton 1977
Whitefish	Coregonus clupeiformis	all	16,613	96	12	50% mortality of juveniles	Lawrence and Scherer 1974
Invertebrates							
Benthic Invertebrates	various	NA	8	25	10	increased rate of drift	Rosenberg and Weins 1978
Benthic Invertebrates	various	NA	62	2400	13	77% reduction in #s	Wagener and LaPerriere 1985
Benthic Invertebrates	various	NA	77	2400	12	53% reduction in #s	Wagener and LaPerriere 1986
Benthic Invertebrates	various	NA	278	2400	14	80% reduction in #s	Wagener and LaPerriere 1987
Benthic Invertebrates	various	NA	743	2400	14	85% reduction in #s	Wagener and LaPerriere 1988
Benthic Invertebrates	various	NA	5108	2400	14	94% reduction in #s	Wagener and LaPerriere 1989

Note: The table does not take into consideration differences in sediment composition

* For explanation of "Stress Rank" see Table 4-5

Tables 4-2 and 4-4, when combined, indicate that the projected increased sediment load should have very little effect on the aquatic life for which data are available. Yellow perch eggs and larvae would be affected by a 10-20 year flood event if the Floodway were used during early-life stages. Benthic invertebrate populations would decrease if the increased TSS lasted for durations of 100 days. Shiners, while showing no physical side effects, would decrease spawning activity during flood events of a 3.3-year magnitude even without Floodway construction.

Given the low possibility of massive flood events during construction, the lethal limits of most of the species for which information is available will not be reached. The chance of detrimental effects from aquatic sediment load on freshwater aquatic life in the Red River due to Floodway Expansion would appear to be low, and restricted to only a few species.

5.0 MITIGATION

Construction of artificial gravel riffles, and sediment traps[2] have been shown to decrease the amount of suspended sand and fine sediments (to a lesser degree) in certain rivers (Avery 1996). Construction of the Red River Floodway expansion is expected to cause minimal increases in TSS, but will be mitigated by:

- keeping the outlet structure culvert gates closed during construction in the Floodway;
- construction of ponds, where and if necessary, to trap and settle sediments; and
- planting of vegetation to reduce bank erosion (Tetr*ES* 2004).

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[2] A sediment trap is a depression which traps particles in flowing water and allows them to settle out.

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6.2 PERSONAL COMMUNICATIONS

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